THE NEXT 25 YEARS IN CANADIAN AVIATION

A presentation by A. V. ROE CANADA LIMITED
to the
Royal Commission on Canada's Economic Prospects

A BRIEF

ON THE

PROBABLE DEVELOPMENTS

IN THE

AVIATION INDUSTRY IN CANADA

AND THEIR EFFECT ON THE

CANADIAN ECONOMY

PREPARED FOR

THE ROYAL COMMISSION

on

CANADA'S ECONOMIC PROSPECTS

WALTER L. GORDON,
Chairman

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Respectfully submitted by

CRAWFORD GORDON, JR.,
President and General Manager

A. V. ROE CANADA LIMITED

INTRODUCTION

The purpose of this brief is to discuss probable developments in aviation and the aircraft industry in Canada in the next twenty-five years and their impact on our economy.

Part I consists of a general review and forecast of world trends, an analysis of their impact on Canada, and finally, a look at the future role of the Canadian aircraft industry.

Part II consists of supporting evidence in the form of charts and statistical data.

All the statements and opinions expressed are based on intensive research conducted by the staffs of Avro Aircraft Limited and Orenda Engines Limited, the two operating companies within the A. V. Roe Canada group most interested in aviation.

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TRENDS IN WORLD AVIATION

There are two dominant factors to be considered in any discussion of probable developments in Canadian aviation in the next 25 years and their impact on our economy. First, although we in Canada have made remarkable progress in pushing back all our frontiers, including industrial, we are no more than on the threshold of our achievements as a nation. Second, although in only a few dozen years human flight has taken its place among mankind's most significant discoveries, man is still no more than on the threshold of his achievements in the air.

Because of geography, Canada's progress as a nation probably depends more than any other on progress in the air. If that progress is to come through the efforts of our own industry, it can only occur if we keep abreast of technological progress and if we are in step with or in advance of design and development elsewhere. It is therefore essential in any review of what may happen in Canada to consider first what may happen aeronautically elsewhere in the world.

The Development Pattern

First, it is necessary to explain the basis for what will be said regarding probable aviation developments in the next 25 years. An examination of the past and present shows that every major advance in aviation has followed a growth pattern comparable to the maturing of a human being.

A very definite period of development is required from the time a new engine, a new aircraft or a new aircraft development or a new technical discovery first appears until it goes into military use and eventually is reflected in civil aircraft. A new engine, for example, may be used to establish a new speed record. It, and the speed attained, then shows up in an operational fighter, then a bomber, then a military transport and finally, when reliability is proven, in a commercial transport. In the early days, this maturing process took about 13 years. Today it takes about 20 years and is increasing slowly, due largely to the increasing complexity of engines and airframes. Only a technological miracle can interrupt this pattern.

Knowing the present speed of research aircraft, and bearing in mind the increasing power of present engines and the influence of new power-plants such as ram jets and rocket motors, it therefore seems possible to forecast with reasonable accuracy the performance of both military and civil aircraft in the next 25 years. Such a look into the future, on a basis which is believed to be conservative, may be necessary to an understanding of the need for long-range planning in the Canadian aviation industry.

Military Aviation

At the outset, it should be stated that military aviation requirements provide the impetus for practically all aeronautical advances. It is a historical fact that, except for one or two cases, every commercial airliner flying today is a direct offshoot of a military aircraft. The reason for this is that the research and development needed to bring about a major advance are so costly that seldom can they be justified from a purely commercial point of view. This limitation does not apply to the military. When it becomes a matter of survival, economics are secondary. The prime governing factor is simply the technological race to build planes to fly faster, higher, and farther than those of any potential enemy. Such technical superiority involves constant replacement of service aircraft and engines with more advanced types. While aerodynamicists work on new configurations to permit higher performance, engine designers are constantly searching for increased power to make such improved performance possible.

Using known developments today as an index and applying our development pattern for projection, it would seem fairly safe to predict that fighter-interceptors will be flying at 1,600 m.p.h. within 10 years. Bombers will be a close second and military and civil transports may reach this speed between 1980-85.

From the present stage of jet engine design and development, we can be sure that within five years a jet will be available which will produce from 20,000-30,000 pounds of thrust or the equivalent, at the speed of sound, of 40,000-60,000 horsepower. Jet engines in service today are delivering up to 10,000 pounds of thrust. We can assume that jet engine power will continue to increase, probably to 50,000 pounds of thrust.

Also, it seems quite certain that as jet engines have replaced piston engines in the military field, ramjets and rocket motors now being tested will replace jets eventually in some uses — such as in unmanned fighters and bombers travelling at speeds and heights unknown today and unattainable by air-breathing engines such as jets.

The use of atomic power in military aircraft also probably is not far off. Its introduction will make a difference mainly in economy of operation and almost unlimited range, rather than in speed and altitude, since atomic energy will be, in effect, a substitute for fuel in already existing power plants. However, until a shielding process can be found which does not involve the tremendous weight of material needed at present, atomic power will be used only in the largest aircraft.

Civil Aviation

The application of all these advances to civil aviation undoubtedly will depend, as in the past, on how quickly they can be proved reliable enough and economical enough for use in transporting passengers and freight. The nature of the advances will be governed by advances in military aviation. However, military aviation by 1980, through increased use of unmanned rocket-powered fighters and bombers, may have ceased to have as close an application to the civil field. If this break in the established military-civil pattern occurs, and it seems highly likely that it will, then after that time the impetus for future civil advances will have to come from somewhere other than the military.

But for the period under study, we believe it is reasonable to assume from past experience that military speeds being achieved today will be introduced to fairly common civil use. By about 1962, we expect most first-line civil aircraft will fly at around 550-600 miles an hour reflecting recent speeds attained by fighters and bombers. Probably by 1970-75, there will have been a jump through the speed of sound to about 900 miles an hour. By 1980-85, speeds of 1,600 m.p.h. being achieved today by research aircraft could be reflected in civil transports.

Passenger Trends

The place these civil aircraft of the future will take in the world transportation picture will continue to be related to considerations of safety and economy. The trend seems obvious. Twenty years ago commercial air transportation was an insignificant factor — in the whole world, less than one billion air passenger-miles were flown. In 1955, Trans-Canada Airlines alone flew nearly a billion passenger-miles; and the world total was 38.5 billion. In 1953, in all types of passenger transportation in the United States, excluding private automobiles and urban transportation, aircraft provided 30% of the total passenger miles. And the closer that air transportation costs come to the costs of other modes of transportation, the greater will be the number of people carried by air. Since 1920 air travel costs have gone steadily down and rail travel costs steadily up. When the lines eventually cross, as seems likely, the aviation industry probably will become the world's prime mover of travellers.

Cargo Trends

In cargo transport, there seems much less immediate prospect of aviation making large inroads into the area now occupied by other modes of transportation, although the volume of freight carried throughout the world has risen from 77 million ton-miles in 1945 to 907 million ton-miles in 1955. Mail carried is up from 90 million ton-miles in 1945 to 257 million ton-miles in 1955. With increasing range and load-carrying capacity inevitably made possible by future developments, a steady acceleration seems indicated. Further developments of turbo-prop engines indicate that transports with an all-up weight of 300 tons will be possible by 1970 and 500 tons by 1975-80 as against about 85 tons for the biggest in service today. Air freight rates, already down almost 70% in the last 15 years, will be lowered much further by the increased ranges and cargo-carrying capacity made possible by these larger aircraft. The application of atomic energy — with lower fuel costs and larger aircraft giving much longer range and carrying capacity at lower price — could revolutionize the field of cargo transportation.

As closely as we are able to determine, these developments in military and civil aviation on a world scale seem likely by 1980.

TRENDS IN CANADA

Aviation in Canada, while mainly in line with world trends, also will be swayed by our specific national requirements both in the military and civil fields.

The trend of events in the next 25 years will depend primarily on national defence and military requirements and to a much lesser degree on commercial needs. Thus, the dominant factor in the future as in the past and present will be Canadian policy, both as to the size and nature of our air power and how such requirements are filled. At the present time, most of the military requirements are met by our own aircraft industry. If this policy is to be continued it is axiomatic that the industry must keep pace with the world and hence must be capable of providing supersonic aircraft powered by more powerful turbojets, ramjets, rockets and, ultimately, atomic engines, and to develop missiles.

Military Requirements

To maintain an air force equipped with the most modern weapons, as is Canadian policy, we will have to replace existing equipment at a rate which will keep our defences equal to any demand. This will mean ever more advanced designs of aircraft which, as at present, will have to operate over vast distances in sometimes bitter cold — conditions which are, among the major air forces of the free world, specifically Canadian.

In the light of today's international tensions there will continue to be a need for Canada to maintain her defences. It is also true that the prime role in defence will be increasingly against attack from the air.

Our primary defence weapon within the next 10 or 15 years will continue to take the form of one or more types of fighter-interceptors. The performance of such aircraft will be related to world trends which implies twice the speed of sound. It is almost certain that in the next decade or so, our defence force will be augmented by ground-to-air guided missiles which will eventually replace manned fighter-interceptor aircraft.

In addition to these primary defence weapons, the following additional support and utility aircraft and equipment will be required: a long-range coastal reconnaissance-type aircraft; short, medium and long-range transports, and to a lesser degree, helicopters. There will also be a requirement for at least two types of training aircraft.

Civil Possibilities

Military aviation is a matter of survival. Civil aviation is primarily a matter of economics in its role in the growth of our economy and in keeping pace with other countries in commerce and industry. To maintain her position as a major trading nation and to continue the development of natural resources Canada particularly will need commercial aircraft of the most advanced types in use anywhere.

The extent to which this newest civil equipment will be used will depend on the ability of air transportation to invade areas now occupied by other modes of transportation. But there will be some special influences here. An extension of our present rate of population increase indicates a possible doubling of population in the next 25 years. If the present relationship between population and gross national product continues, this will result in a quadrupling in our gross national product. This is bound to have a considerable effect on civil aviation.

Also there is one Canadian area in which aviation stands virtually alone — the north.

Any map of Canada, showing highways and railroads and even water routes skirting the vastnesses where most of our undeveloped natural resources lie, demonstrates the importance of aviation in what is bound to be accelerating development of our north. Aviation's speed, lower capital outlays in instituting service, and ability to reach otherwise inaccessible areas already have been instrumental in establishing the air lines in this field.

Besides the many day-to-day jobs aircraft perform in the north, we have mines which were prospected from the air, whose men and equipment were taken in by air, whose products are taken out by air, and which are served by air in all respects. Parts of the Kitimat project would have been impossible without air transportation. Uranium mines which have made us the world's second greatest producer of this vital mineral are served by air — and so are the towns which sprang up around them. In the great Quebec-Labrador iron ore development, more than 150 million pounds of freight were transported by air. Construction and servicing of the Distant Early Warning radar line is only possible through air transportation.

These and many more airborne developments are striking enough. Even so, compared to our future northern development they may be like the first homesteaders who reached Western Canada before the end of the last century — the trickle which precedes the flood. Canadian aviation seems likely to play as important a role in opening up our north as Canadian railroads played in opening up the west.

The great need in this northern push, even today, is an all-purpose aircraft designed to meet northern conditions — rigorous climate, long ranges, remote airports with short runways. In addition to its commercial role it would have a military function as a troop and supply transport. A transport of this kind would be ideal on the DEW line and other radar line projects.

In addition to this specific requirement, and in view of our general potential for expansion within our borders, there should be an expanding market for a trans-continental transport; a medium range transport; possibly one or more types of smaller transports such as the de Havilland Beaver or Otter; helicopters and private-owner aircraft. Outside our borders our growth will also mean a growing market for a large trans-oceanic transport.

Should a military program of the extent indicated be carried out over the next 25 years, it would be logical to assume, in the light of the established military-civil relationship and the growth potential for civil air transportation that it would be accompanied by a commercial program. With the possible exception of the very large trans-oceanic and trans-continental types, it would seem reasonable that all other commercial types should be produced in Canada. Since the military program is bound to result in the increasing establishment of subsidiary industries, it follows that the bulk of the components and accessories for commercial production should also be produced in Canada.

THE ROLE AND IMPACT OF OUR INDUSTRY

Having reviewed likely developments in world aviation, and looked at what will probably happen in Canada, the final question is: Where should the Canadian aircraft industry fit in and what will its impact be? This must be considered in the light of Canada's policy as to the role the industry should play in supplying our future military and civil aircraft and engine requirements. The factors involved may be divided into the following main groups:

1. The advantages or original design and development.
2. Our technical ability to compete in this exacting field.
3. Our ability to compete from the standpoint of costs.
4. A long range policy.
5. Economic factors.
6. Taxation.
7. Exports.
8. Technological impact.

The Advantages of Design and Development

The foundation of the aircraft industry in this and all countries has been, is and for the period under review will most likely be predicated on the needs of national defence and military requirements. If it is accepted that an efficient air force is needed, it must follow that an efficient aircraft industry must also be maintained. An aircraft industry is an essential integral part of an air force.

And because an air force must be free to choose its own weapons, the industry must be technically competent to design and develop and produce whatever is required. If the Canadian aircraft industry is to fulfil this role as the industrial arm of the air force, and keep it supplied with up-to-date equipment, then it follows that it can best be done with products of our own design and development. The alternatives are buying directly from another country, or building in Canada from foreign designs under a license from the designer. In time of war, experience has shown it is virtually impossible to buy first line aircraft or engines from another country. They quite naturally want for themselves all the most modern weapons they can build. Disruption of transportation is another important consideration. In the last war, we had air-frames sitting on the ground without engines to power them. Dependence upon foreign supply then may be termed, at best, an uncertain answer to Canada's needs. This has already been recognized and for the most part, our air force requirements are met out of Canadian production.

Keeping an air force up-to-date by manufacturing under license has its problems too. The process from design to prototype takes several years, even in the designer's home plant. There is another several months or a year before quantity production can be reached — and it is at that stage usually that a product is considered ready for licensing to another company or country. Then it will take the licensee a year to 18 months to tool up and get into production. The result is necessarily a product in which several years of technological progress have not been taken into account.

This latter handicap can be minimized or even eliminated if the country acquiring the license has design and development facilities of its own. Canada's experience with the United States-designed F-86 Sabre is a good example of this. With the Canadian Orenda jet engine, the F-86 V and VI being built by Canadair is superior to those produced by the original manufacturer. However, the ability to undertake this sort of development depends on whether such engineering and production capabilities and facilities exist. We are fortunate in Canada that such capabilities and facilities do exist.

A final vital consideration is that when an air force is looking for a certain type of aircraft to have built under license, it may not be able to find the type it needs — as was the case in the middle forties, leading to our own design and development of the CF-100 all-weather day-night interceptor and the Orenda jet engine.

It would appear illogical then to contemplate a policy which would preclude all design and development in Canada and one which would require that all of our defence equipment be created in some other country. For these reasons, but primarily for reasons of national security, it would seem to be essential that a large part, if not all of our air power requirements be designed and developed in Canada.

Are We Technically Capable?

It is largely from A. V. Roe Canada's experience with the CF-100 and the Orenda and the Jetliner that we can answer the question as to whether Canada is technically qualified to compete with the world's aircraft and engine designers. The evidence shows that we are. In the important field of time — accomplishing an objective at competitive speed — the performance of Avro Aircraft and Orenda Engines on these projects compared well with new developments at about the same time by British and American companies. In quality too, they met admirably the job for which they were designed.

The Jetliner was a casualty of the Korean war. It had to be shelved to concentrate on defence projects. But by being the first jet-powered transport to fly on this continent by five years and by its fine flying record since, the Jetliner is a monument to our technical ability.

The CF-100 has been developed steadily in line with latest defence requirements by Avro Aircraft. And Orenda engineers have developed a steadily increasing rate of power from their engine, at a steadily decreasing weight.

As for today and tomorrow, the engineering and research capabilities and facilities that exist are, we believe, keeping us abreast and possibly ahead of others. Avro is developing a supersonic interceptor, the C-105; Orenda, a new jet engine, which opens up new vistas of power and is advanced in the use of titanium. In addition, Avro has a contract with the United States government for the development of what has been termed a "revolutionary new aircraft concept". All this is very tangible evidence of our ability to compete technically.

Can We Compete In Costs?

From the viewpoint of national security which is the prime consideration, the case for design, development and production in Canada has been established. Economics are secondary. However, the evidence is that it costs no more to do our own design and development. Orenda design and development costs compare favorably with a comparable British engine and are *lower* than the average U.S. costs. We compare favorably, too, on the CF-100. But in addition to straight cost comparison, this factor must be considered: Because of the decision to proceed with our own design and development, we have been able to establish engineering and research facilities that never existed before, thereby adding to the industrial and technological stature of our country. By the same token, this benefit would have accrued to other countries, if we had not gone ahead on our own. The value of this development cannot be measured in dollars and cents.

As for production costs, the CF-100 and the Orenda which are as good if not better than anything available elsewhere, have been delivered at prices below what we would have had to pay elsewhere. The CF-100 costs substantially less than a comparable U.S. aircraft while the Orenda is several thousand dollars cheaper than its U.S. counterpart. This is on the basis of production of more than 400 CF-100's and over 3,000 Orendas.

As to whether our production costs as compared to those two countries is likely to change in the future, this will be determined largely by labour rates and by the fact that aircraft production costs are greatly influenced by the quantity produced. Our costs at present are generally lower than those in the United States despite our lower production runs, but are slightly higher than in Britain due to Britain's much lower labour rates.

This competitive position has been achieved through the development of plant and engineering and research facilities which rank among the best in the world. The aircraft industry in Canada today comprises four major aircraft plants, three engine plants and another 43 plants in which manufacture of aircraft or engine parts is either the whole or chief occupation. In addition, a supply network of 2,500 other companies has been built up — many with new plants or expanded facilities designed primarily to serve the aircraft industry. The people employed directly by the aircraft, engines and parts industries total 35,000. The department of labour has estimated that another 35,000 people in the industry's supply network are engaged specifically on aircraft or engine components. These plants and skills have made the Canadian aircraft industry competitive technologically and in terms of production with any in the world.

A Long Range Policy

To translate this initial performance in original design and development and production into terms of long-range service to our country and the impact on our economy, one of the greatest needs is a long-range policy. The aircraft industry cannot be started and stopped, like mining or lumbering, and still remain efficient. Building aircraft and aero-engines is essentially a technological race. Any interruption causes a falling behind which, at the very least, is difficult to make up. We now have a good position in this race. To hold it — and, in effect, enhance the national investment we have made — we need a long-term summation of our future requirements, and a long-term plan to meet those requirements. Such a plan might cover such related matters as:

1. Expansion of research and testing facilities.
2. Consideration of a production program to ensure continuation of operations at a level which would permit the industry to retain essential engineering and production staffs and keep plant facilities in constant readiness for rapid expansion should the need arise.
3. Assess the long-range demand of such a program for engineering and technical skills and talents and consider ways and means of making them available.

Already there is an acute shortage of engineers, particularly in the aircraft industry. Our own companies are having to range far beyond Canada to get the people we must have if our various projects are to proceed on schedule. The need is so urgent that it calls for joint action by industry, educational authorities and governments.

In considering this long-term policy and its impact, possibly the most important thing to remember is the dominant part military aviation plays. Civil aircraft are developments of military aircraft and for the most part are secondary to the demands of national defence. This, of course, does not always follow. The need for commercial transports is sometimes equally compelling. A classic illustration is the Canadian airlift for the DEW line where scores of transports are needed. Even here national defence is at the root of the need. And defence, directly or indirectly, in peace or war, is everybody's business and is financed from public funds.

By its very nature, aircraft design and development cannot normally be financed by private enterprise, which depends for its existence on investment of its capital in profit-bearing activities in which the return is fairly immediate. In contrast, design and development of aircraft involves the expenditure of vast sums and there is no possibility of any immediate financial return at all. Development of a jet engine of a competitive size today takes from five to seven years from original design until it is put into service and involves many millions of dollars. With the risk involved in uncertainty of production quantities, because of inevitable changes in technological and possibly also in defence requirements, an investment of this size without government participation has little or no attraction for private capital. However, some firms have carried the early stages of a development as a private venture to demonstrate the potential of the concept. In

Canada, this has been done by members of the A. V. Roe Canada group.

The same principles apply to military and civil airframe development. A current estimate would be a cost of $30 millions to develop a large commercial transport airframe (exclusive of engine development), and the developing company would have to sell at least 100 to break even.

To illustrate this point, there are only 207 heavy transports in Canada today. T.C.A.'s total fleet, including several kinds of aircraft, numbers 69. Therefore it will be seen that private financing of such ventures — commercial transports, engines or fighters — is practically impossible. The only exception is in light, uncomplicated private and small commercial aircraft. This also is the case in Britain and the United States, where the twin issues of national security and national progress and prosperity have prompted those governments to become intimately involved in long-range participation in virtually all major aviation developments.

Economic Factors

In considering the long-term application of such a policy in Canada, and the impact of the industry on the Canadian economy, a number of factors should be borne in mind. The costs of design and development are large — but the money is spent in Canada on salaries, wages and raw materials. When aircraft or engines are bought abroad, this money spent outside of our country is a direct drain on Canadian public funds without any financial return whatever. In building aircraft of foreign design under license, the licensing costs are high. Also, a royalty must be paid on each aircraft or engine produced. Such payments go out of the country to help support foreign industrial development, rather than our own. An additional cost in using foreign designs is that of modifications to suit our specific operational requirements.

Also, there are great advantages to maintenance of a Canadian design in Canada beyond the all-important strategic factor of the air force having control of defence supply in its own hands. Perhaps the most significant advantage from a national point of view is that we have established engineering and research facilities that never existed before. This has added measurably to the technological and industrial stature of our country. Furthermore, it has provided challenging opportunities for engigineers which, to a large extent, has helped stem the flow of our best skills and talents to other countries. In fact, in some cases, the flow has been reversed, which is recognition indeed of the advanced character of the projects we have underway.

When these matters are added to the fact that using the CF-100 and Orenda as examples, our costs per product are lower than the price we would have to pay elsewhere, the original costs of design and development take on a less formidable aspect. For instance, to buy another aircraft designed for the job of the CF-100 — but not doing it as well — would cost the Canadian people substantially more per aircraft than they pay for each CF-100. When this is multiplied by the number of these aircraft now in service, millions of dollars have been saved by having the aircraft made at home.

Taxation

A further effect of home design is on taxation. When equipment is purchased outside the country, the costs we pay includes taxes levied in that country, and is a direct drain on Canadian public funds without any return whatsoever.

On the other hand, when such equipment is produced at home, the tax content of this selling price is returned to the Canadian treasury. Some idea of extent of this return can be gathered from the fact that the value of all the aircraft industry's products in 1953 was $400 million.

In addition, the money spent goes directly into the Canadian economy in the form of wages and salaries, and much of this is recovered in the form of income and corporation tax. Again, an indication of what this amounts to can be gathered from the fact that the total of all salaries and wages in our aircraft industry in 1953 was roughly $140 million.

Since it would appear almost certain that Canadian requirements for both military and civil aviation are going to increase, these factors of cost, taxation and the impact on the economy generally will assume still greater significance.

Exports

In another form of impact on the national economy, it can be expected that as the Canadian aircraft industry develops, it not only would be capable of supplying most of our own needs, military and civil, but also through exports could contribute to those of the rest of the free world.

We know that exports to other countries are largely affected by national policies and resulting trade regulations, but the country able to develop and produce designs technically and economically superior to others will, as in the past, overcome these barriers. Good examples are the de Havilland company's fine light transports, the Otter and the Beaver, both designed and produced in Canada. They are sold in 40 other countries simply because they are best in their field. Opportunities for such exports are possible only when a country designs and produces her own products.

Technological Impact

The effect of an aircraft industry on a nation's technological progress and industrial growth is almost imponderable. No other industry of any significance requires the refinements and improvements necessary for success.

When these improvements have been made in the aircraft industry, other types of industry are able to take advantage of them. Some of the areas particularly affected in this respect are, in electronics, performance in improvement of power plants, in development of materials, in educational standards of engineering, and in production processes and methods.

One of the best-known examples of the aircraft industry's development of materials is aluminum. The main impetus came from the need for a light, strong metal for aircraft. Today aluminum and its alloys find more than 80% of their total use outside of the industry. The search for lighter and stronger metals and alloys in building aircraft and engines is a constant process. The newest is titanium. It supplies a strength equivalent to that of steel, with only 60% of the weight. Although at present titanium is used almost entirely in the aircraft industry, it undoubtedly will find many applications elsewhere as the supply goes up and the price down — for example, in road and rail transportation where greatly increased pay loads could be carried by increasing a vehicle's size without an increase in weight. Power plant improvements due to the development of the jet engine also have brought technological advances of direct concern to other forms of transportation, as well as to the generation of electric power. Without the pioneering of the aircraft industry, few of these advances would have been attained for many years to come.

From all these considerations, the general effect of a strong aircraft industry on the whole Canadian economy becomes apparent. Future industrial development in Canada, in relation to that throughout the world, will have a considerable dependence on the aircraft industry in avoiding the costly time lags inevitable if, without an aircraft industry of our own, we always had to learn industry's newest lessons second-hand.

The industrial aspect is vitally important. But the prime consideration is that freedom depends largely on the possession of superior weapons by free men of good-will. In this, the relationship of the air force and industry is that of a closely-knit team — airman and engineer. This teamwork will become more and more important as greater and greater stress is placed upon technical advancement in defence, a word which now is almost synonymous with strength in the air.

The aircraft industry is an integral part of the air force, creating and producing and keeping modern the best in weapons, which our defenders always will deserve. And because of the very direct relationship which exists between military and civil aviation, as our aircraft industry grows in strength to meet our defence needs, it also will be in a position to meet the continuing need for advanced commercial aircraft so essential to the continued expansion of our country during the next 25 years.

In Conclusion

Canadian aviation has made great strides in the past 10 years. The aircraft industry has expanded and its base has been broadened and reinforced through the establishment of its own research and designed facilities and the acquisition of new industrial techniques and capability. In the jet engine field, a whole new industry has been born. With it came new plants, expansion of old ones, new techniques and know-how and new engineering facilities. A measurement of our progress is that when we started to build the Orenda, 95% of the components in it came from *outside* Canada. Today, the situation is reversed; 95% now come from *inside* Canada. In varying degrees the same trend occurred in airframe manufacturing.

The result of this Canadianization has been a significant increase in total employment and in the value of production. In 1950, for example, the aircraft industry stood 40th in manufacturing in terms of the factory value of products. Today it is in ninth place. This, with today's levels in employment and salaries and wages, puts the aircraft industry in the same economic class as automobile manufacturing, iron and steel products, railway rolling stock, electrical apparatus, etc.

The following comparative estimate for 1955 with automobile manufacturing indicates the growing importance of the aircraft industry.

	Factory Value of Products	Employment	Salaries and Wages
Automobile & Parts	$650,000,000	50,000	$187,000,000
Aircraft & Parts	400,000,000	35,000	140,000,000

This industrial and economic growth, and the aeronautical achievements of the past 10 years, are the direct result of private initiative and investment and a progressive national policy which supported the concept of a self-sufficient aircraft industry capable of undertaking original design and development.

In the next 25 years, the industry's importance in the economy of our country and throughout the world should increase at a far greater rate. Unless there is an unexpected change in the international climate, there will be a continuing defence requirement. Then there is the tremendous potential for expansion through the inevitable invasion by air transportation into areas now served by other forms of transportation.

Because of these two factors alone, aviation could well become the foremost industry in the world in the period under review. In Canada the probability is heightened by the additional factors of geography, our increasing population, and the vital role of the aeroplane in the development of our vast natural resources.

The sole governing factor in the attainment of this potential economic stature is national policy. Only through a long-term programme can we maintain an aircraft industry capable, first of all, of meeting our defence requirements, and second, able to provide, on a competitive basis, commercial aircraft for Canada itself and for export, and by so doing contribute to the fulfillment of the rich promise of Canada's future greatness as an industrial nation.

PART II — CHARTS AND STATISTICS

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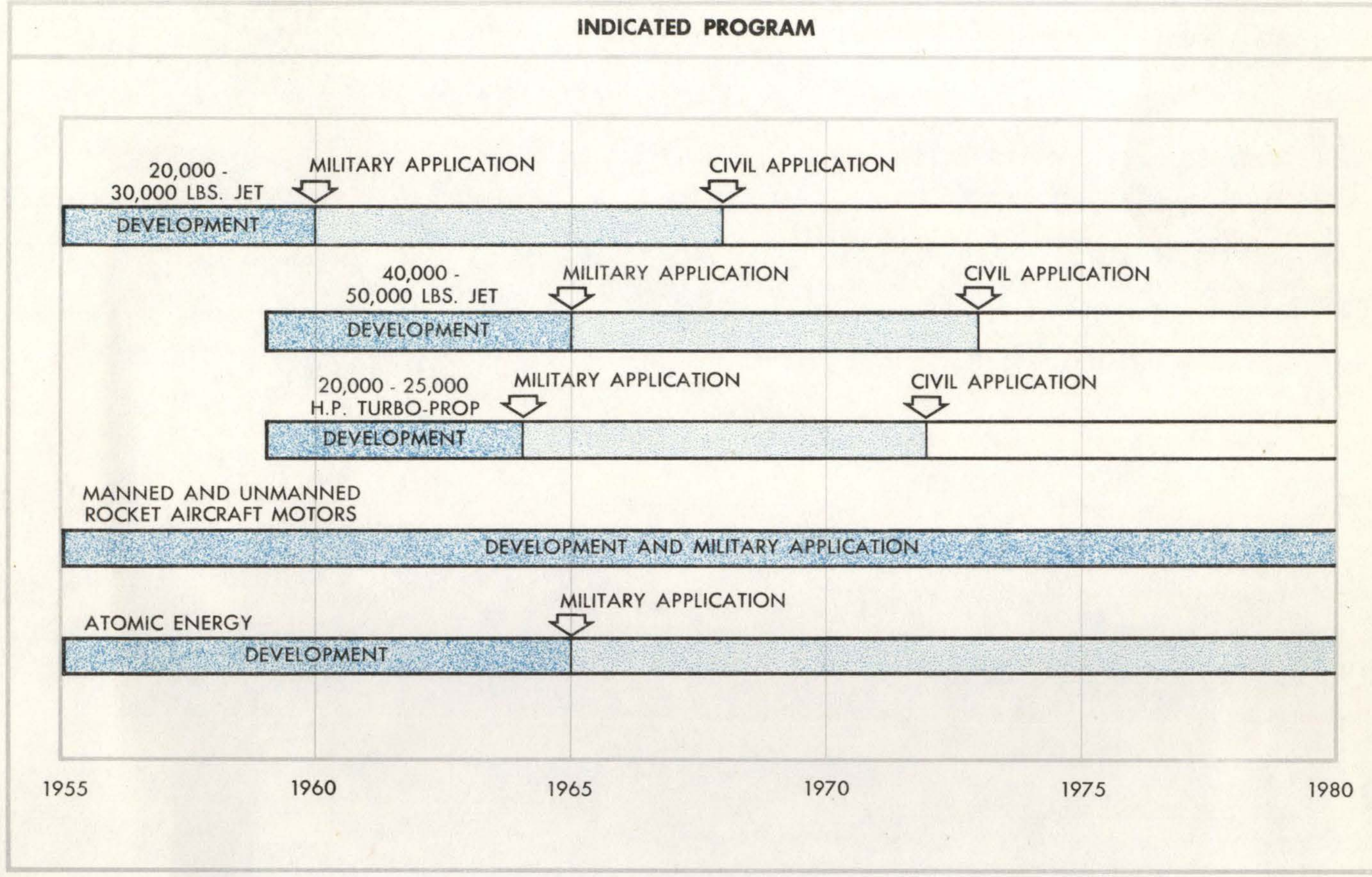
12. The Future.



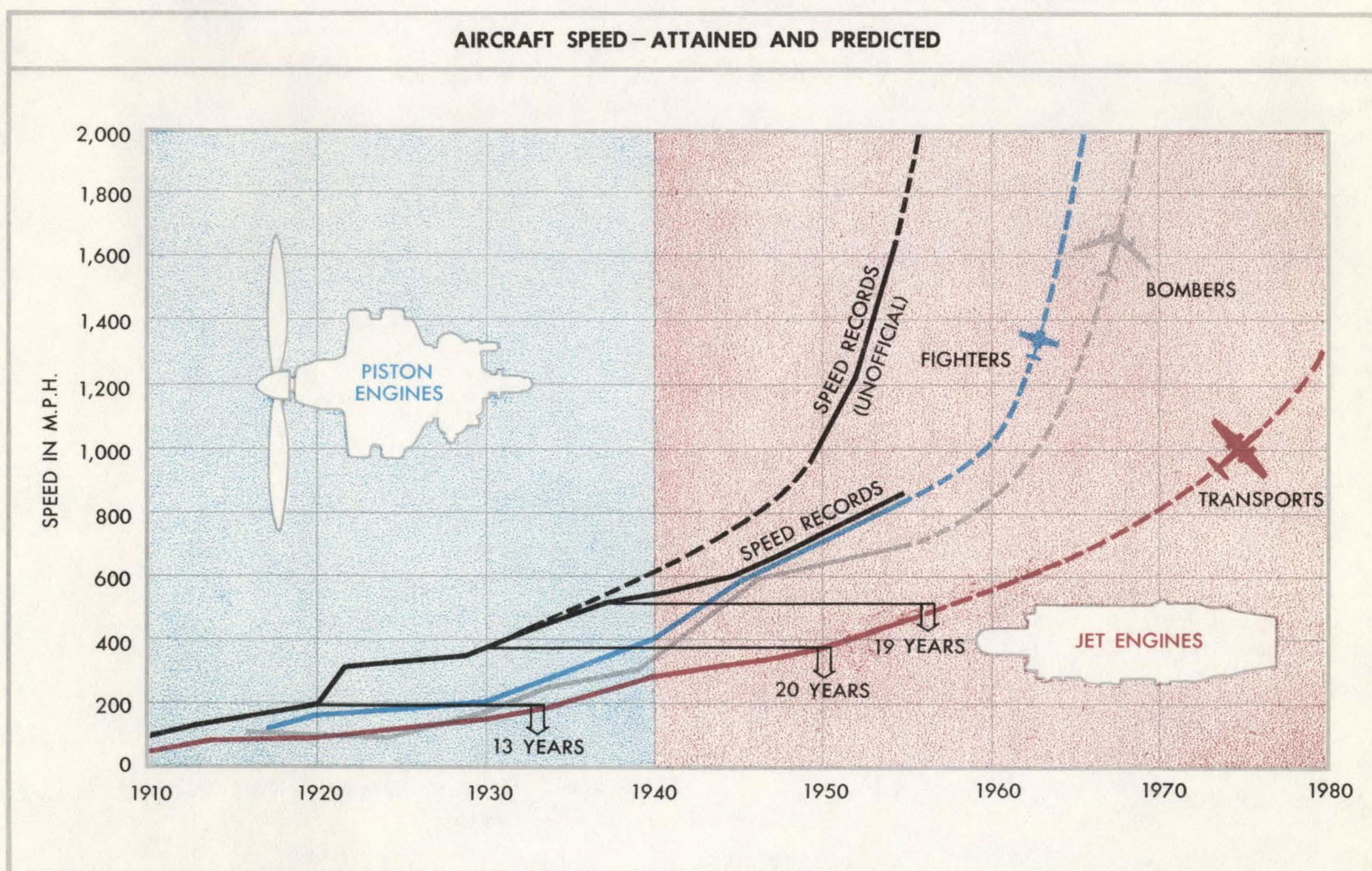


Chart No. 1

PATTERN OF DEVELOPMENT

Major advances in aviation have followed a common pattern. As indicated in these two charts, a very definite period is required from the time a new speed record, improved performance, airframe development or a new engine first appears until it goes into military then civil use. Usually, improved performance first shows up in research aircraft, then in operational fighters, then bombers and military transports and finally, when economy and reliability are highly developed, in civil transports.

Except for major innovations such as the introduction of the jet engine and the establishment of initial speed records by operational rather than research aircraft, the various curves of development follow a fairly uniform pattern in relation to each other and to the whole. Only a technological miracle can interrupt this pattern.

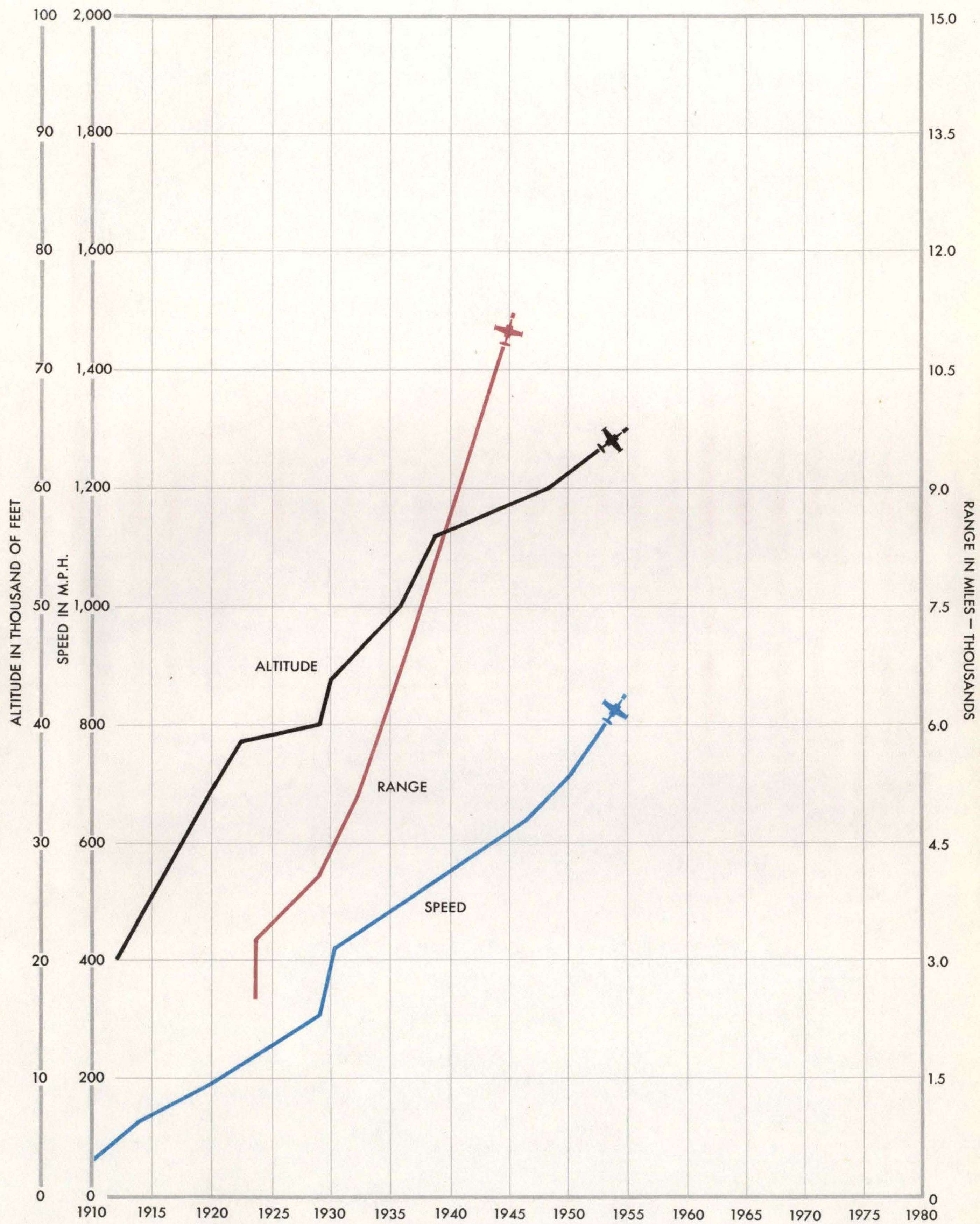
In the early days, the period of maturity from the establishment of a speed record until it was reflected in civil performance was about 13 years. This has been increasing slowly until today the whole process takes from 20-25 years. This lengthening time lag is due to the increasing complexity of aircraft and engines.

Therefore, knowing the present speeds of research aircraft and bearing in mind the increasing power of present engines and the likely influence of new powerplants such as rockets, aeronautical engineers believe it possible to forecast with reasonable accuracy the performances of military and civil aircraft within the next 25 years.

The fastest speed attained so far by manned aircraft is 1,650 m.p.h. by a rocket-powered research aircraft in December 1953. Using this as an index and applying the established growth pattern, fighter-interceptors should be flying at this speed within ten years and civil aircraft between 1980-85. Confirmation of this time lapse is that it is eight years since the speed of 967 m.p.h. was reached by a rocket-powered experimental aircraft yet this speed has not yet been attained by operational aircraft. The closest to it is 822 m.p.h. reached by a jet-powered fighter in December 1953.

The key to this continued development is power. It takes about five years from the beginning of design to the time an engine can be used as the sole source of power in a fighter aircraft. If the development of turbojets and turboprops is commenced as indicated in the upper bar chart, then the overall predictions are feasible.

However, the time is coming when the traditional relationship between military and civil aviation may not exist to the same degree as today. It appears almost certain that jet-powered manned military aircraft will be largely replaced by rocket-powered missiles. When this time arrives and it could happen in the next two decades, military requirements will be so different from civil requirements that a marked divergence in the present development pattern will occur. From then on, the impetus for civil aviation development will have to come from elsewhere.



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ALTITUDE, RANGE AND SPEED RECORDS

Chart No. 2

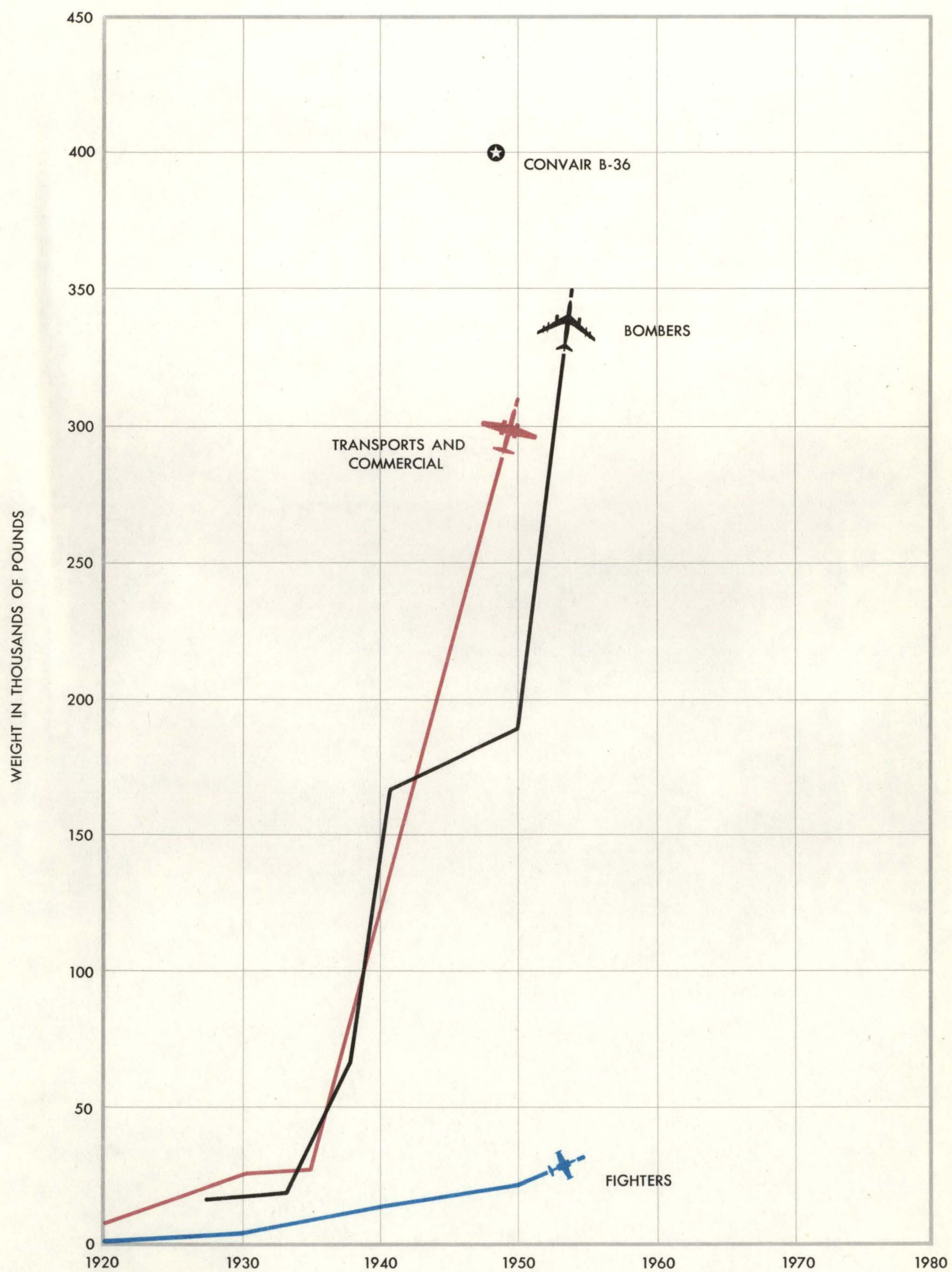
ALTITUDE, RANGE AND SPEED

The highest altitude yet attained by man is about 90,000 feet—in an experimental rocket aircraft. An altitude of from 90,000-100,000 ft. is the likely limit for air breathing power plants such as jets. Rockets, which do not depend on the atmosphere for combustion, have no known limit.

Range is chiefly dependent on the amount of fuel that an aircraft is able to carry. Present fuel weights have been the main factor in limiting the present range record (without in-flight refuelling) to about 11,000 miles. The next major advance in range is likely to come with the development of atomic power as a substitute fuel in already existing power plants. Because of its insignificant weight, atomic fuel will make possible a vastly increased range. But until a shielding process can be found which does not involve the tremendous weight of material needed at present, atomic power will be used only in the largest aircraft.

An increased use of unmanned fighters and bombers—at speeds and altitudes unknown today—probably will take place by 1980.

By then, civil passenger transports probably will travel at about 1,600 miles an hour, having reached that rate progressively after research powerplants and airframe materials have been proved reliable by military aircraft.



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AIRCRAFT WEIGHT

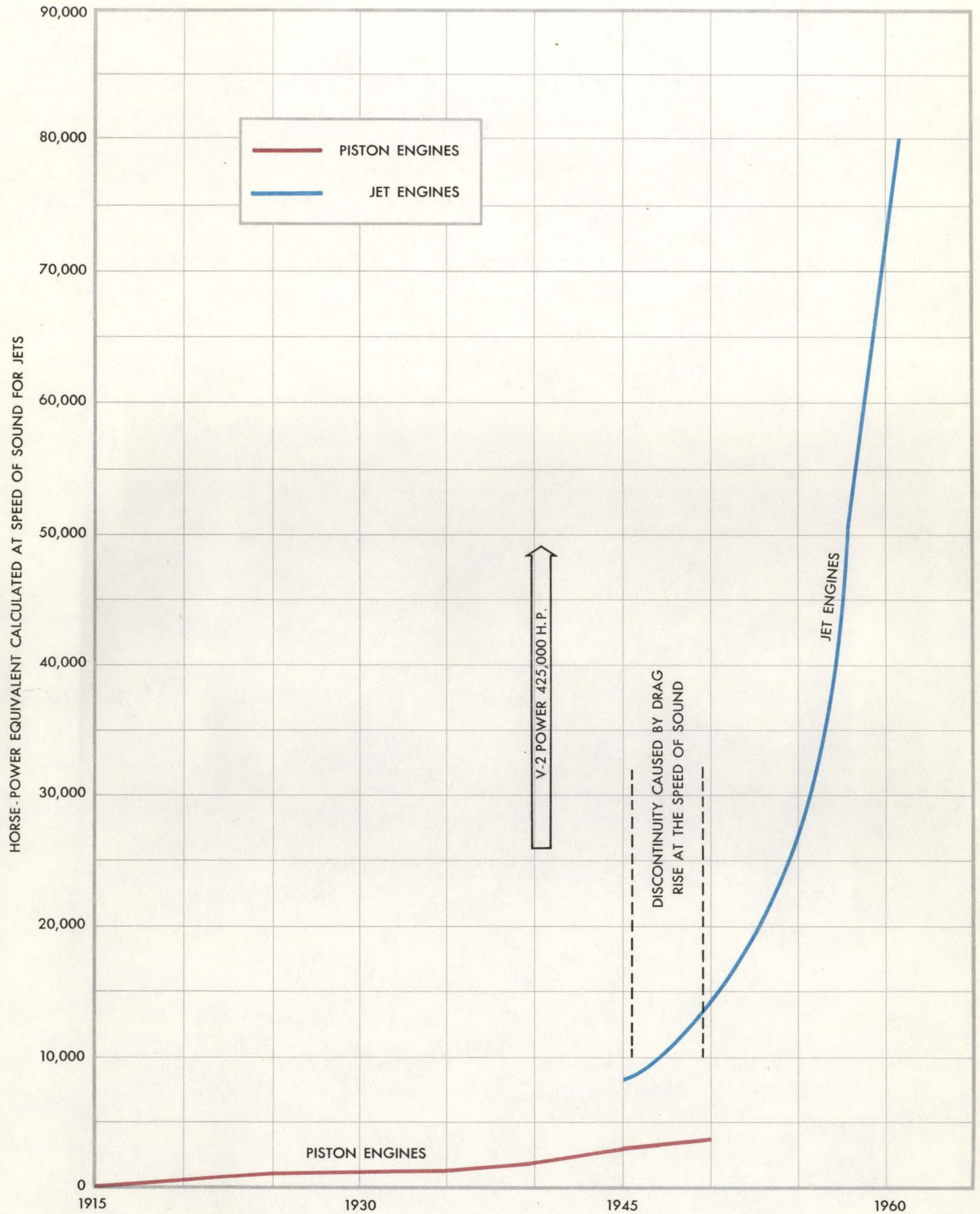
Chart No. 3

AIRCRAFT WEIGHT

Weights of all types of aircraft are increasing constantly and rapidly. In 1935, military transports weighed about 12 tons—less than the weight of the modern long-range jet fighter. The largest transport in the world now, the Saunders-Roe Princess, a flying boat, is 180 tons. Other transports at around 85 tons are in quantity use. The progressively greater demands being placed on transport aircraft seem to ensure a continuation of this growth in weight. By 1980, the biggest transports may weigh 500 tons or more.

This estimate is based on transports now in existence:

	All Up Weight	Horse Power	WT/HP Ratio
Boeing Stratofreighter C97A	153,000	14,000	9.15
Douglas Globemaster.....	175,000	15,200	8.168
Saunders-Roe Princess.....	315,000	28,200	8.195



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AVIATION ENGINE POWER

Chart No. 4

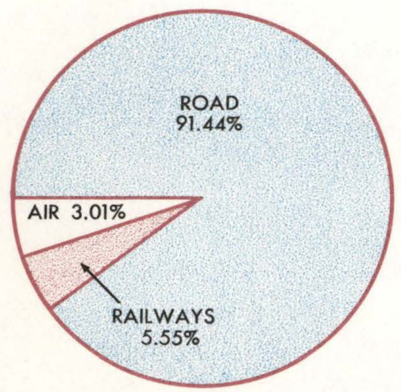
AVIATION ENGINE POWER

Increases in engine power naturally must be concurrent with increasing aircraft weights and speeds. Turbojets in common use today produce from 7,000 to 10,000 pounds of thrust or the equivalent of 14,000-20,000 horse power at the speed of sound. Engines being designed or developed today will produce double or triple that when they are introduced to service, probably within five years.

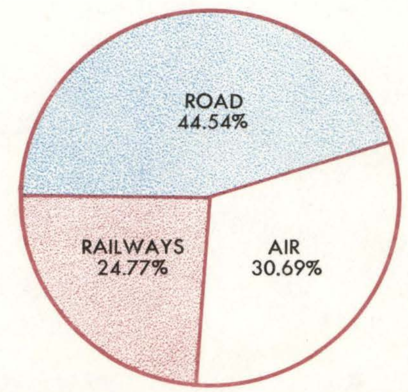
The more economical turboprop versions of these turbo-jets probably will be the main commercial transport engines in the 1970's.

The most powerful turboprop engine in existence today develops about 15,000 horse power. By using four of these engines in a transport, 60,000 horse power is possible and, using as a rough indication a weight-horse power ratio of 9 to 1, this would provide a transport twice the size of the largest one in existence today.

Further developments of turbojet engines would increase this power greatly if these were converted to turboprops. From 20,000 to 25,000 horse power is possible, which would provide us with enough power to fly at an all up weight of 500 tons.

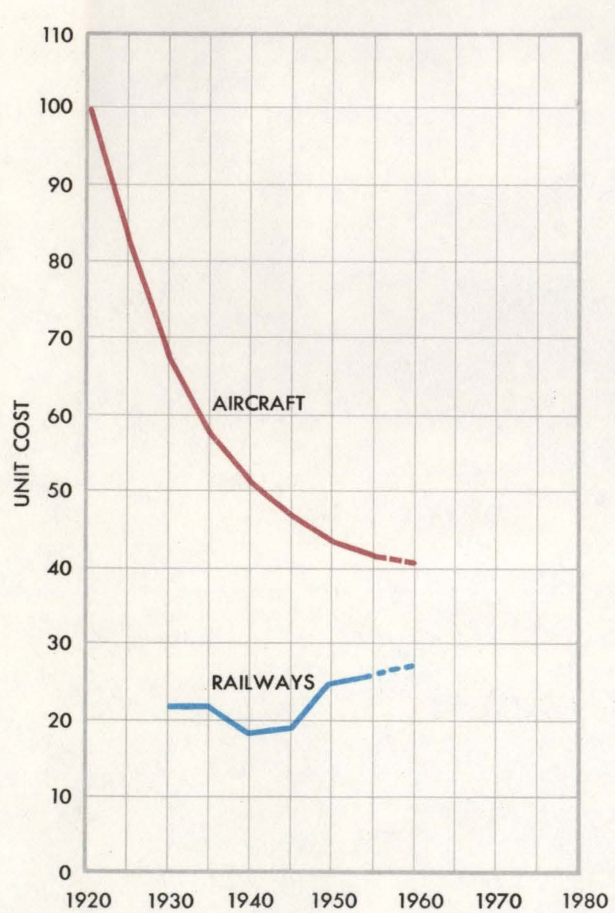


PER CENT DISTRIBUTION U.S. PASSENGER MILES 1953
(INCLUDING PRIVATE AUTOS)



PERCENT DISTRIBUTION U.S. PASSENGER MILES
(EXCLUDING PRIVATE AUTOS)

COST PER PASSENGER MILE



WORLD PASSENGER MILEAGE TRENDS

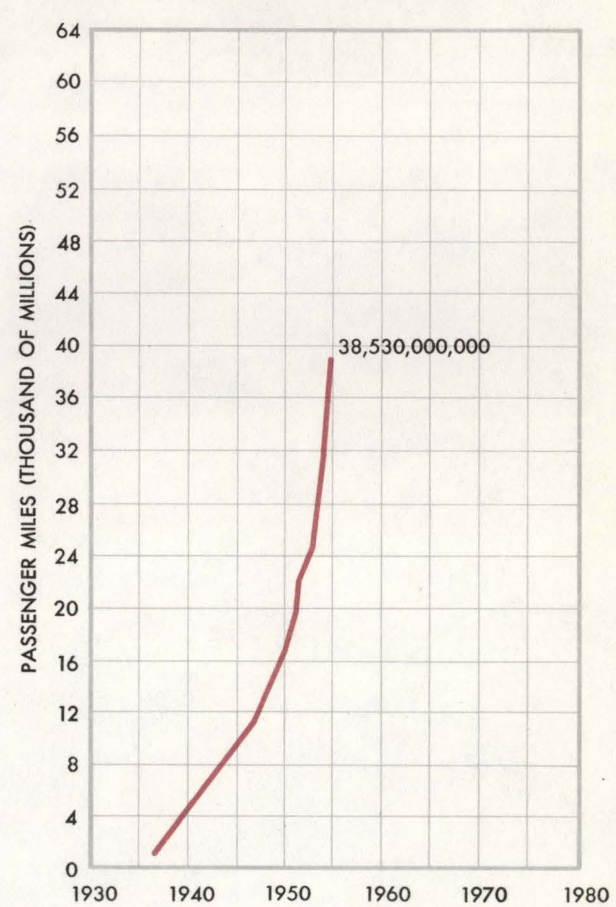


Chart No. 5

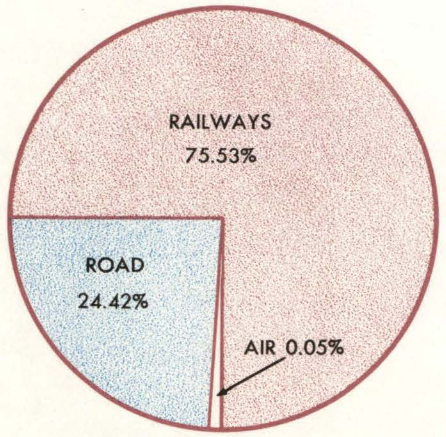
COST, MILEAGE TRENDS

As in the past, expansion of civil aviation as a passenger carrier is primarily related to steadily increasing efficiency of equipment, as reflected in safety and economy. As costs of air transportation come down and costs of other means of transportation go up; more and more people will travel by air. A recent division of the market by the main means of transportation in the U.S., excluding passenger autos and urban carriers, is shown here as indicative of the trend now being felt in Canada, and elsewhere. The steadily dropping cost also applies to other countries in varying degrees.

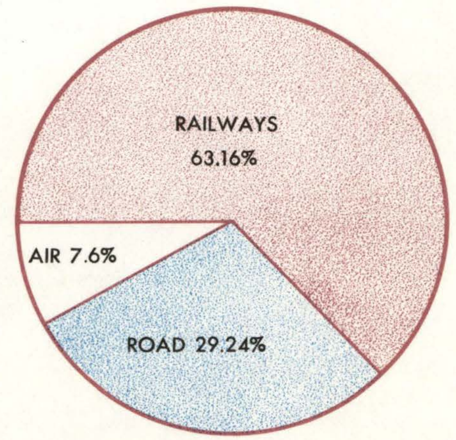
The latest available details on development of world civil aviation (not including the Soviet Union and China), were issued a month ago by the International Civil Aviation Organization. They include only details of scheduled services, both international and domestic. The most striking statistics are those showing that since 1950, the number of passengers carried and number of passenger-miles (passenger-mile: to carry one passenger one mile) flown has increased by more than 100 percent.

Development of World Civil Aviation

Year	Passengers Carried (Millions)	Passenger-Miles (Millions)	Av. No. of Passengers per Aircraft
1955	69.0	38,530	27.4
1954	59.0	32,620	25.8
1953	52.4	28,900	24.8
1952	45.0	24,540	23.2
1951	39.9	21,380	21.9
1950	31.2	16,960	19.1
1949	26.5	14,480	17.3
1948	23.5	12,990	16.5
1947	21.0	11,740	16.6
1946	18.2	9,630	16.5
1945	9.3	5,100	13.7
1937	2.5	800	5.3

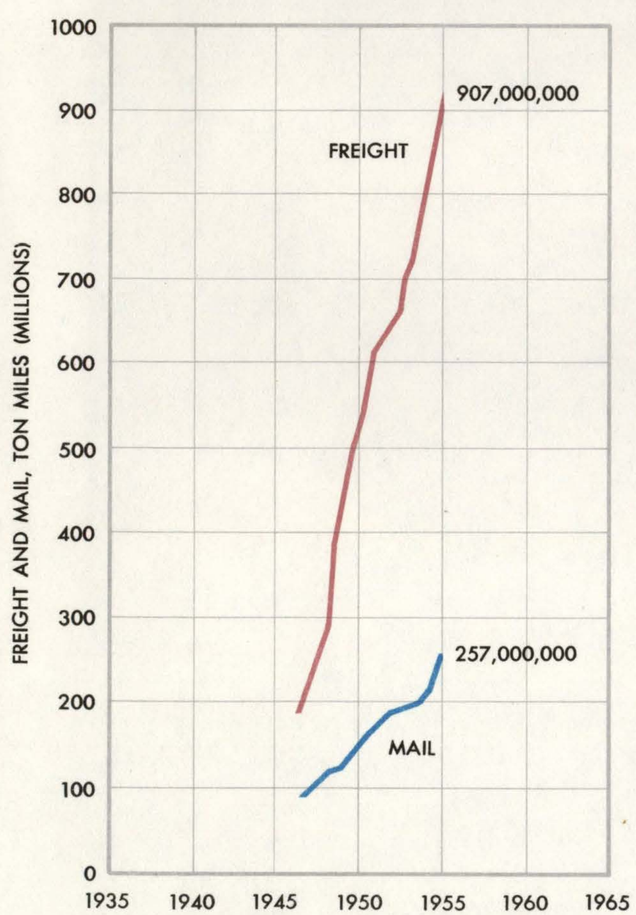


PERCENT DISTRIBUTION U.S.
CARGO TON MILES 1953



PERCENT DISTRIBUTION U.S.
GROSS REVENUE 1953

WORLD AIR FREIGHT / MAIL MILEAGE TRENDS



FREIGHT COST PER TON MILE (U.S.)

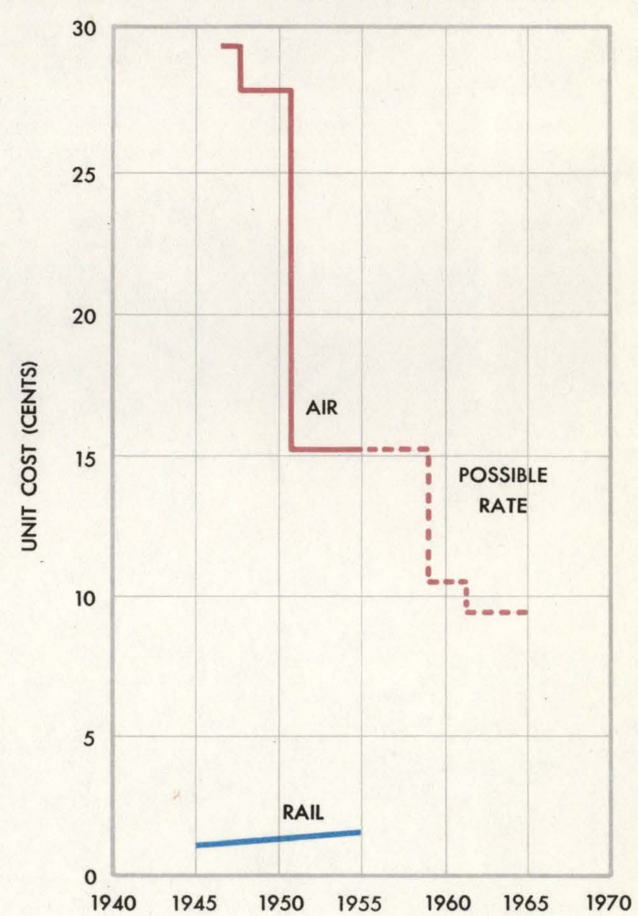


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Chart No. 6

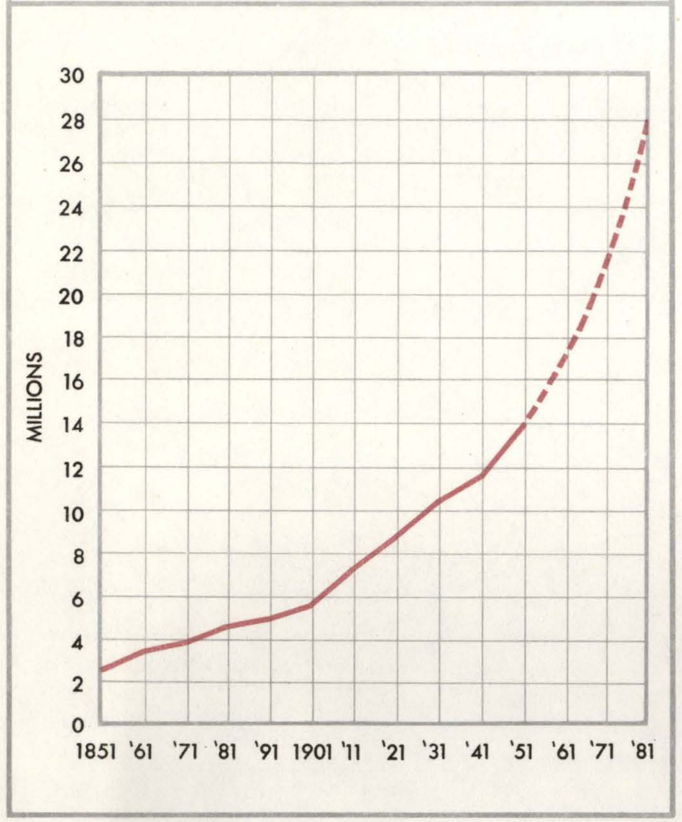
WORLD FREIGHT-MAIL TRENDS

Since 1945, cargo and mail air traffic has increased rapidly. In 1945, 77 million ton-miles of cargo were carried by scheduled airlines throughout the world (excluding Soviet Union and China, for which figures are not available). In 1955, the figure was 907 million ton-miles. The increase in mail ton-miles over the same period was from 90 million to 257 million.

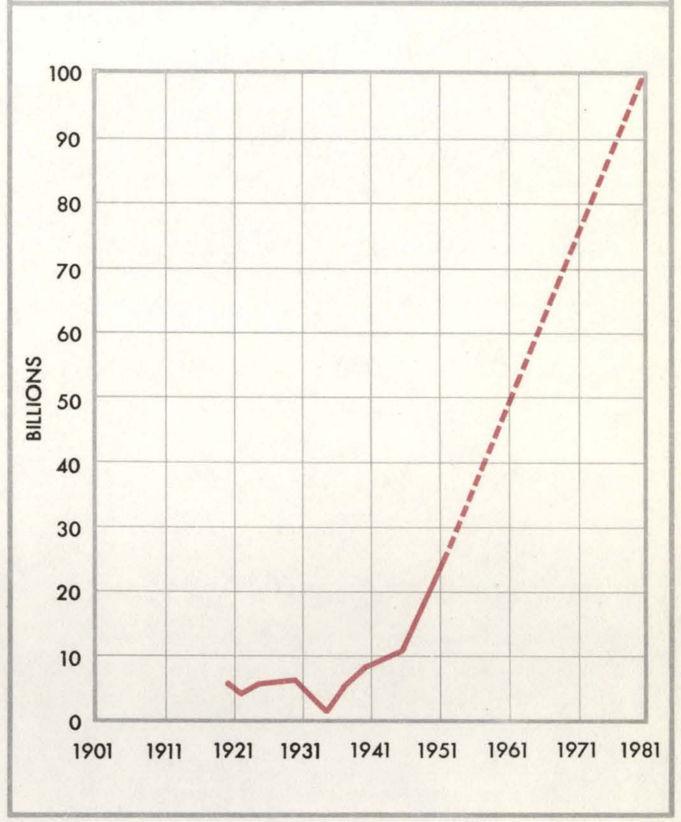
These figures still leave aviation carrying less than one percent of the world's total freight—a vast area for expansion in the future era of increasing aircraft range and load-carrying capacity.

As in the passenger-carrying field, the U.S. figures for air transport's 1953 share of ton-miles and revenue, are indicative of the world trend; as is the steady decrease in air cargo costs.

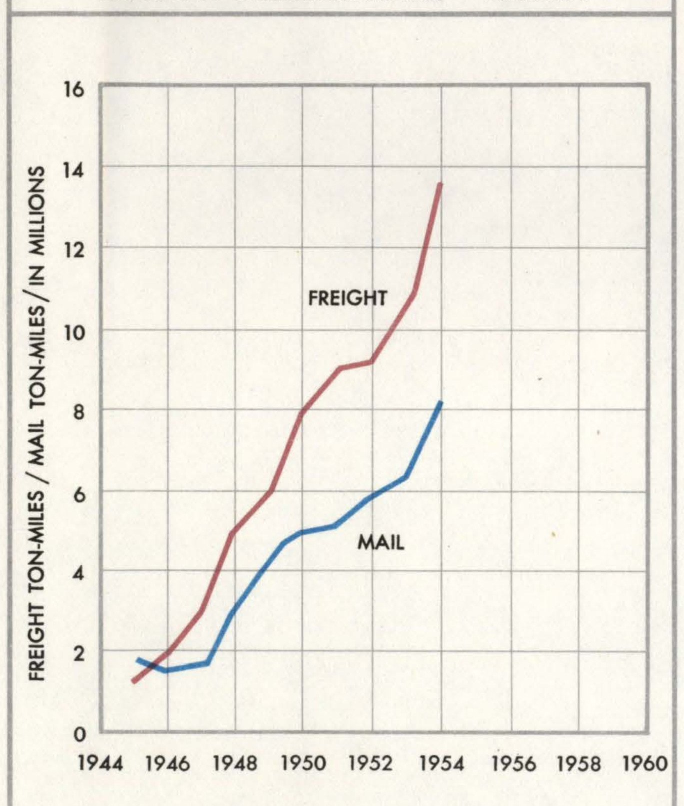
GROWTH IN CANADA'S POPULATION, 1851 to 1981



GROSS NATIONAL PRODUCT TREND



CANADIAN CARRIER STATISTICS - AIRCRAFT



PASSENGER AND FREIGHT REVENUE - CANADA 1954

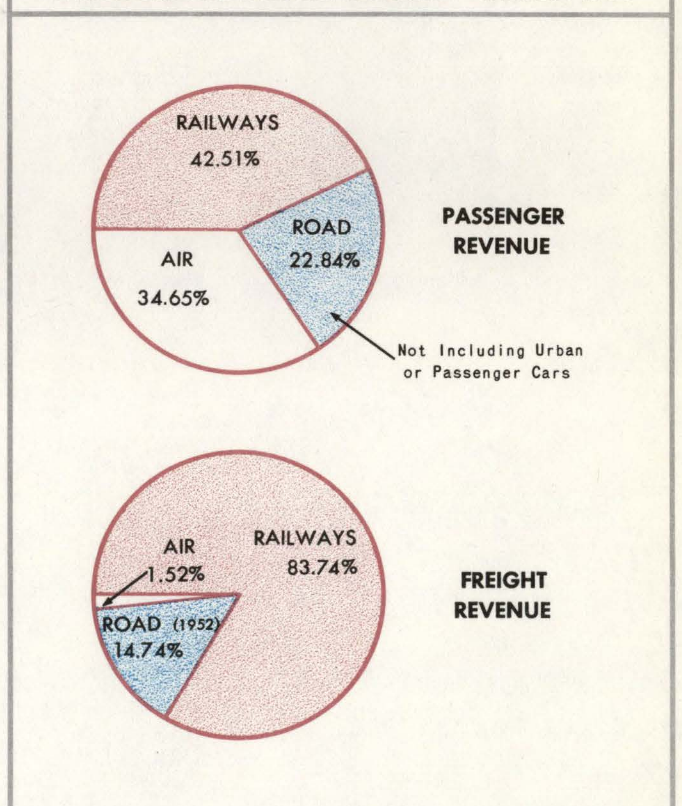


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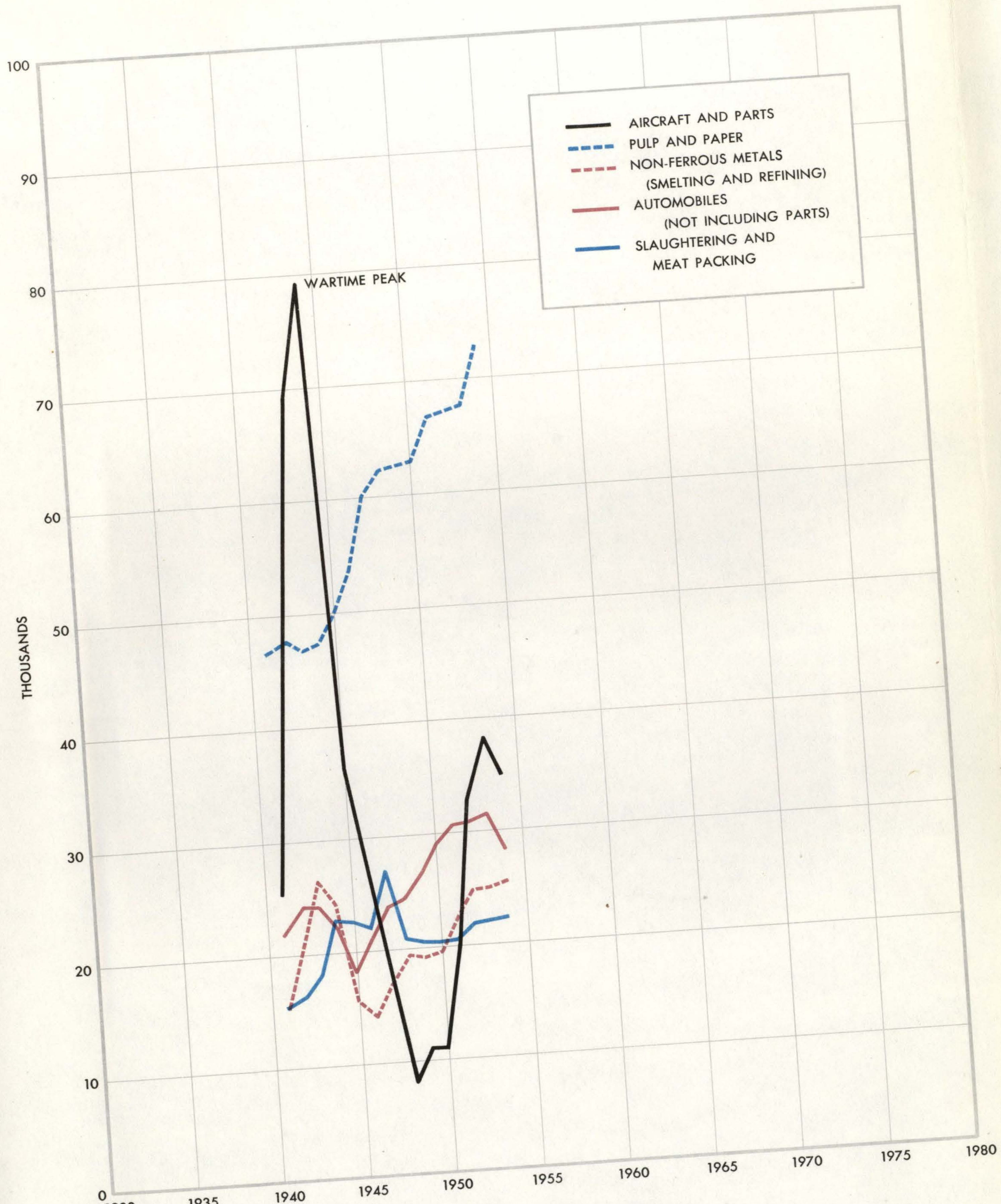
Chart No. 7

NEW MARKET POSSIBILITIES

World developments in military aviation seem certain to be followed in Canada in most main respects—new shapes and speeds for aircraft, more powerful jets, guided missiles, rockets, and atomic engines.

In civil aviation, new markets will be created by Canada's swift rate of development in population and industrial strength and capacity. Our geography is another influence. The advantages of air travel are multiplied when long distances must be travelled. In the north, where development of natural resources seems a great part of our nation's future, aviation has no rival—and this development is just beginning.

These factors will affect aviation in Canada to a degree unparalleled elsewhere in the world, and must therefore be added as a powerful imponderable to the already steadily-increasing share aviation is getting of the Canadian transportation market.



NUMBER OF EMPLOYEES IN AIRCRAFT INDUSTRY

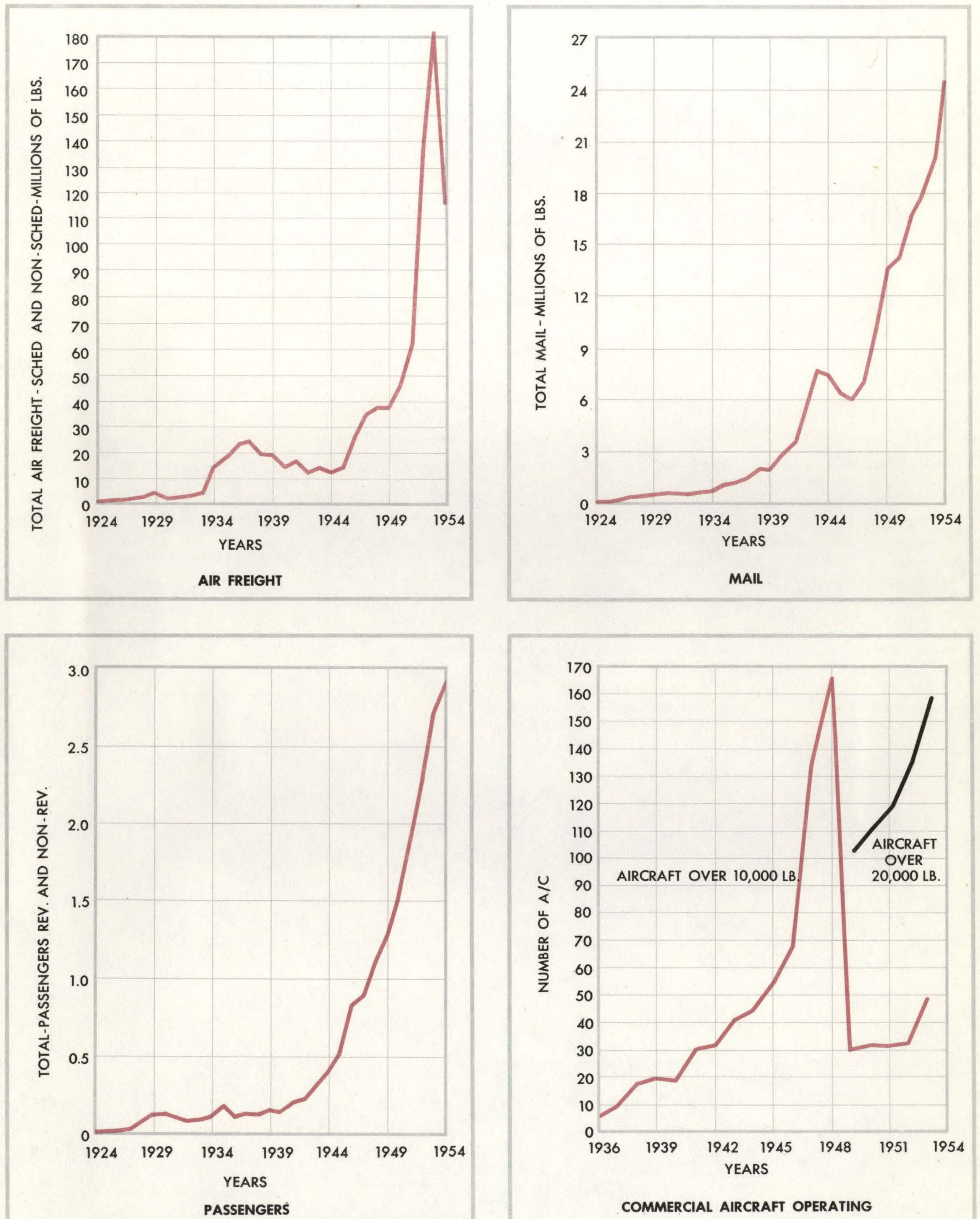
1212-MS-1

Chart No. 8

EMPLOYMENT

The Canadian aircraft industry comprises four major aircraft assembly plants, three engine plants and another 43 which manufacture engine or aircraft parts. The number employed is about 35,000; their salaries and wages total about $140,000,000; the value of their gross national product is about $400,000,000 (in 1953).

In addition, a labor department estimate is that in the 2,500 companies whose production in whole or in part helps supply the aircraft industry, another 35,000 Canadians are engaged directly in work for the aircraft industry.



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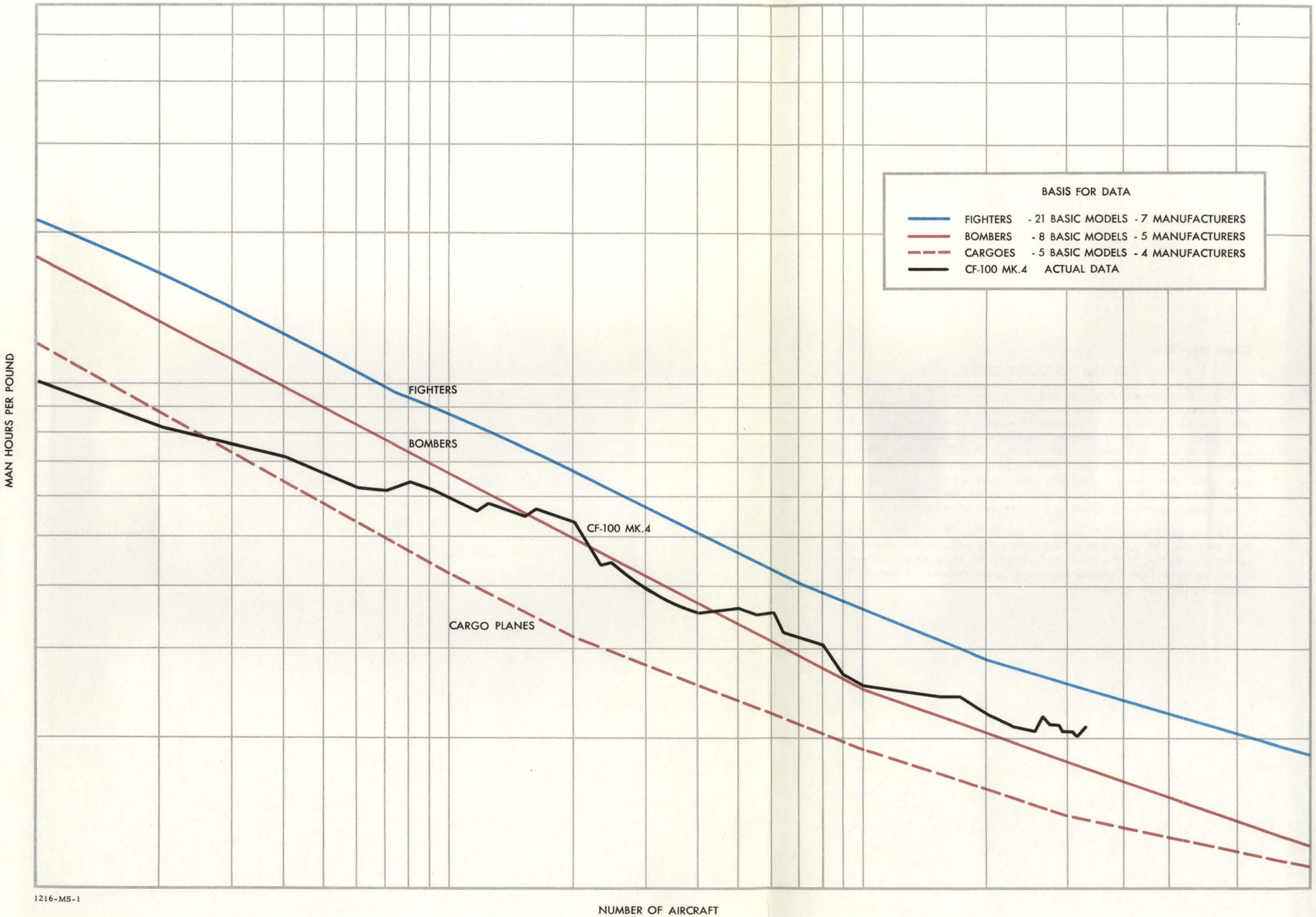
CANADIAN AIR CARRIER STATISTICS

Chart No. 9

GROWTH FACTORS

The rate of growth in Canada has been no less remarkable than elsewhere in the free world. In 1944, about 150 million passenger-miles were flown. Ten years later this increased to more than one billion. As air transportation costs go down and other carrier costs go up, this trend seems certain to accelerate year by year.

Rate of growth is equally striking for cargo. In 1944, about 3 million ton-miles were flown. In 1954, this increased to 22 million ton-miles. However, this expansion has made very little in-road into total cargo hauled by all carriers. Based on revenue for 1951, air transportation accounted for less than 1% of the total. Future developments in large-cargo carrying transports and passenger transports indicate great potential for expansion.



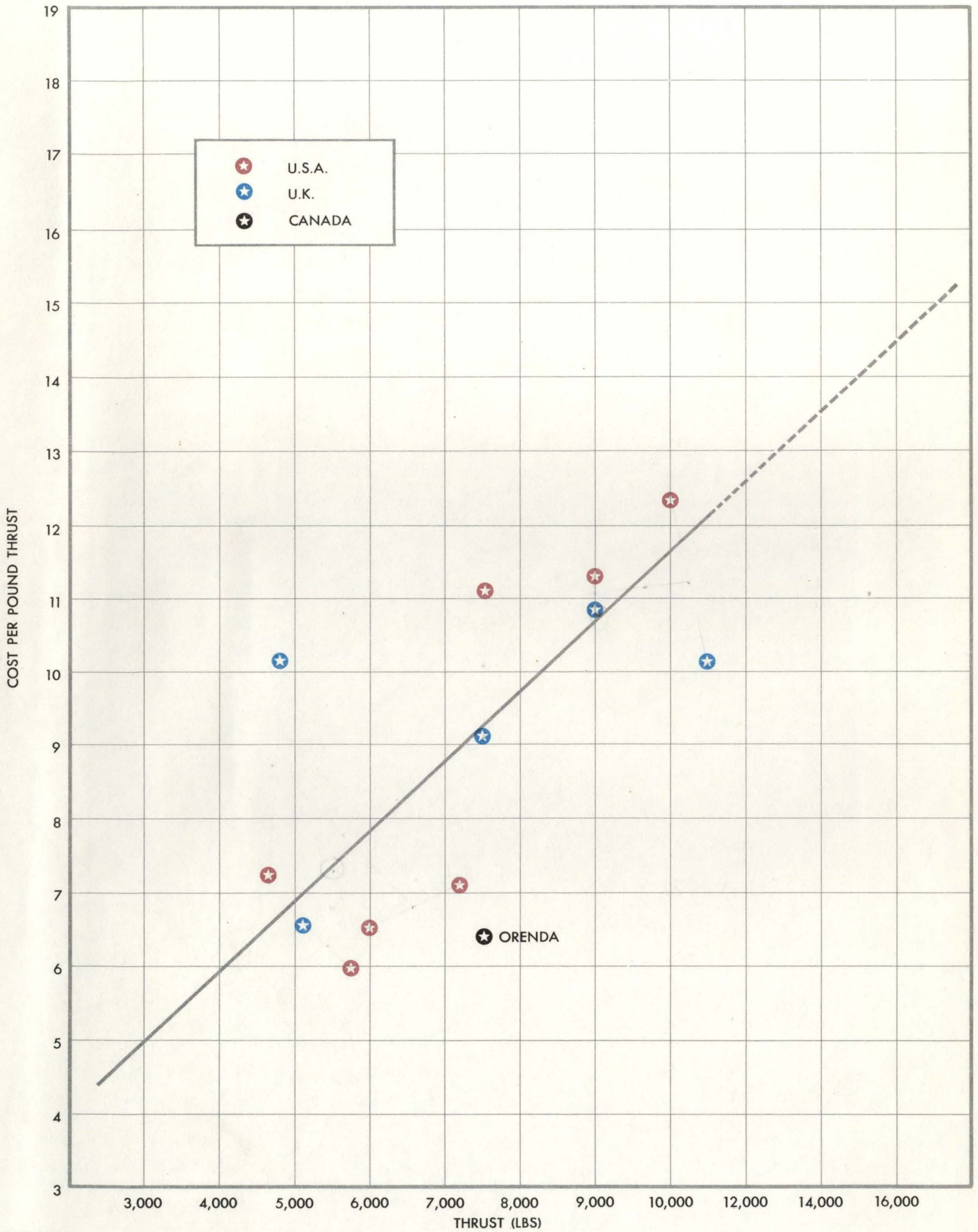
MAN HOURS PER POUND PER AIRCRAFT - POST WAR PERIOD

Chart No. 10

CF-100 AIRCRAFT COSTS

There is convincing evidence that in the ten years since 1945 when it has been Canadian policy to provide some of our defense equipment from original design and development our development and production costs have been quite favorable. Equipment that has been designed and developed in Canada—notably the CF-100 and the Orenda engine—is as good if not better than anything available anywhere else and it has been delivered at prices below what we would have had to pay elsewhere. The accompanying chart shows the CF-100 man-hour curve running generally below average United States fighter costs.

To buy another aircraft to do the job of the CF-100—but not do it as well—would today cost substantially more per aircraft. If this unit saving is multiplied by the number of aircraft and engines now in service, it can be seen that Canada has been saved millions of dollars by producing her own equipment.



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COST COMPARISON OF JET ENGINES - U.S.A., U.K. AND CANADA

Chart No. 11

ORENDA COSTS

The accepted yardstick of jet engine cost is the ratio of total cost to pounds of thrust delivered. On this basis, as shown in the accompanying chart, the cost of the Orenda is lower than engines of comparable power developed in the United States and Britain in about the same period. This is on the basis of more than 3,000 Orendas produced.

At the same time, design and development costs compare favorably with British manufacturers and are lower than average United States costs.

THE FUTURE

There is one Canadian area of transportation in which aviation stands virtually alone—the north. Highways and railroads and even main water routes skirt by hundreds of miles the vastnesses where most of our undeveloped natural resources lie. Aviation's speed, lower capital outlays in instituting service, and ability to reach areas otherwise inaccessible already have established air lines in the north—and no other transportation medium can come close in terms of cost of service.

Already we have mines which were prospected from the air and which are now served by air in all respects. The Kitimat Hydro-aluminum project would have taken much longer but for air transportation. Uranium mines which have made us the world's second greatest producer of this vital mineral are served by air and so are the towns which sprang up around them. More than 150 million pounds of freight were shipped by air to open up the great Quebec-Labrador iron ore development. Construction and servicing of the Distant Early Warning radar line is only possible through air transportation.

These and other air-borne developments are striking enough. But compared to our future northern expansion, they are much like the pioneering of the homesteaders who pushed their way into Western Canada before the end of the last Century and were the trickle before the flood. For some time we have been expanding out of the narrow strip along our southern border to open up the north. Increased population will obviously stimulate this trend. So will the discovery of new natural resources. So will the development of bigger, more economical, more efficient aircraft. The vastly lower capital cost of aircraft compared to other means of Northern transportation, plus the ability of the airplane to reach places inaccessible by **any** other means—at **any** cost—will continue to make our northern development as completely the province of the airplane as our westward development was of the railroads. This, with steady expansion in scheduled air line operations, and in the light of military requirements, clearly indicates the potential growth of Canada's aviation industry.