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'JET PROPULSION AND THE GAS TURBINE'

ANNOUNCER: The jet propulsion aircraft is in these days often in the news, but so far, it hasn't been possible for people who are interested to obtain a very clear idea of how it works - or of the connection between jet propulsion and the gas turbine.

Well, in this talk Dr. Roxbee Cox, Chairman of the Government owned Power Jets company, is going to describe jet propulsion and the gas turbine and explain how they are related.

Dr. Roxbee Cox.....

ROXBEE COX: First of all, I want to try to make the nature of jet propulsion clear. Imagine yourself standing, shod with very smooth-soled shoes, on a very smooth floor. Now suppose that, with eyes front, you whistle very vigorously. The result will be that you'll move backwards. Mind, I did say imagine this, because if you really tried this experiment it's very unlikely that it would prove successful. It isn't possible to get floors and shoes smooth enough, nor to blow hard enough, to produce the result, but this supposed experiment does illustrate what is called "Newton's third law of motion". This law says that to every action there is an equal and opposite reaction, and when expelling from the mouth a jet of air in the act of whistling, there must be a tendency for the whistler to retreat.

Jet propulsion is a very old idea. The whistling experiment I've described may well have been used by Hero of Alexandria over two-thousand years ago, when he had to try and explain to his friends why the jet propulsion engine which he had designed, worked. The idea of jet propulsion was also familiar to Newton, two-hundred-and-fifty years ago, and, coming to our own times, it is the principle on which that whiligig kind of lawn sprinkler works.

Now for the gas turbine.

While there are many kinds of engine for providing power, they fall into two main classes. In the first class are engines like those in the locomotive and the motor car, in which pistons are forced to move to and fro in cylinders, and in which this to and fro, or reciprocating, motion is translated by cranks and connecting rods into rotational motion. These are called reciprocating engines. The second class is one in which a drum, or a disc, on which is mounted a number of blades, is driven round because a fluid such as water or steam or gas is forced past the blades. These are called turbines. Just as a wind blowing past the blades of a windmill makes the windmill rotate, so does the fluid forced past the turbine blades make the turbine rotate.

The steam turbine is of course widely used to drive ships, particularly the very largest ships. It is also used to generate electricity in power stations. Where great water power is available, as at Niagara, Boulder Dam or Dnepropetrovsk, water turbines are used to convert the power into electricity. The application of the gas turbine, however, has so far been very limited. This is because, although the gas turbine dates back to John Barber's patent of 1791, its development has been held up by lack of suitable materials. The gas turbine, to be efficient, must be allowed to get very hot inside, and not until recently have the metallurgists been able to make materials which are sufficiently strong when red hot. Since they achieved this great technical feat a few years ago, the gas turbine has become a very practical engine. Even before the war the Swiss had built a locomotive driven by a gas turbine, and had installed another in the electrical power station at Neuchatel.

Well, so far, I have talked about two different things, firstly jet propulsion, and secondly gas turbines. I now want to get on to the connection between them.

The outstanding characteristic of the engine invented by Frank Whittle is the association of jet propulsion and the gas turbine. He put forward in his first patent in 1930 the use of the gas turbine to produce a powerful jet. The gas turbine is particularly fitted for this

duty, because it takes in large quantities of air and thrusts out large quantities of gas, and you will appreciate that the greater the quantity of gas which is thrust out backwards from a jet, the bigger is the raction which drives the jet-propelled vehicle forward. The Whittle jet propulsion engine is therefore appropriately called a jet propulsion gas turbine. It is, when compared with the modern aircraft reciprocating engine, a very simple machine. Air is taken into a compressor, and after being compressed is led into combustion chambers where its mixed with fuel and burned. The result is a great volume of gas which passes through a turbine, thereby driving it round. The purpose of the turbine is to drive the compressor. Leaving the turbine, the gas streams back as a hot, high velocity jet and it is the reaction from this jet which drives the aeroplane forward.

But the gas turbine can be used to drive aeroplanes in other ways as well. It can be made to drive a propeller just as the old reciprocating engine does. It can be made very conveniently to drive a new, especially small, kind of propeller which works in a tunnel. This kind of propeller is called a ducted fan.

These applications are in some circumstances more economical to use than the jet propulsion gas turbine. Some engineers believe that the very lowest fuel consumptions will be obtained by combining a special form of reciprocating engine with a gas turbine, but in general, the lower the fuel consumption the heavier and more complex the engine is. The jet propulsion gas turbine, as I've said, is a very simple machine, and it has in essence only one moving part, the rotor, that's to say the compressor, the turbine and the shaft joining them. So one can't help feeling sorry that the drive for greater economy will tend to destroy this delightful simplicity, particularly as the fewer parts there are to move, the fewer parts there are to go wrong.

The most suitable type of gas turbine engine for a particular aeroplane, depends very much upon what the aeroplane is required to do; and generally for a given range we would choose the type for which the weight of the fuel, plus the weight of the engine, is the lowest. In other words, we might find that for a relatively short-range aeroplane, a very

light engine which burned a lot of fuel, was, in fact, more economical than a more complicated and heavier engine which burned less fuel. The important thing, as I have said, is the combined weight of the engine and the fuel for the journey.

The gas turbine is going to make a tremendous difference to air transport. If full advantage is taken of this new form of engine, aeroplane cabins will be very silent and free from vibration. Tremendous speeds and exceptional ranges will be possible; travelling at five hundred miles an hour will become commonplace, and it won't seem at all unusual to get to New York in five or six hours. Whether all this rushing about is going to be good for us is arguable, - but not now.

The gas turbine has a great future in ships, as well. It's as smooth running as the steam turbine, it can be just as efficient, and, as it needs no boilers, it's more compact.

As I've already hinted, it has possibilities for Power Station work too, and can be used for hauling trains. I've no recent information about the Swiss Power Station gas turbine I mentioned, but the Swiss locomotive has been running very reliably on the Swiss Federal Railways, and has shown itself to be more economical than the diesel-electric locomotive, which is its natural competitor.

But in this country it was the aircraft world that showed the way in gas turbine development, and the results of Air Commodore Whittle's pioneer work are now seen in Royal Air Force planes. He had, to begin with, great difficulty in getting his ideas put into practice, but in 1937, a company called Power Jets Limited, was formed by friends of his who had faith in his schemes. This company ordered an engine to Whittle's designs from the British Thomson-Houston company and this engine ran successfully on the test bench in 1937. Thereafter, with the backing of the Air Ministry, Power Jets Limited developed Whittle's ideas and on May 14th 1941 - only four years ago - the first British jet propelled aeroplane successfully flew. I saw it and I shall never forget the thrill. The aircraft had been built by the Gloster company to the designs of Mr. W.G. Carter, the engine had been built by the British Thomson-Houston company to the order of Power Jets Limited and to Whittle's designs. The pilot was the late Flight Lieutenant

Sayer. This was a momentous day in the history of British aviation. Both aeroplane and engine performed perfectly. Thereafter the plans of the Government for jet propulsion gas turbine aeroplanes were rapidly expanded. The researches which had been in progress at the Royal Aircraft Establishment, leading to a different form of engine, were accelerated. Other engine firms capable of taking part in what was clearly a revolutionary development, were brought into the picture, and since 1941 Power Jets Limited, the Royal Aircraft Establishment and the technical teams of the de Havilland, Metropolitan-Vickers, Rolls-Royce, British Thomson-Houston and Armstrong Siddeley companies, and later the Bristol company, have worked in very close collaboration.

Also in 1941 the Government decided to collaborate with the Government of the United States of America, and it was a dramatic moment when on September 29th 1941 a Liberator left Prestwick for Washington, carrying a jet propulsion engine, a complete set of drawings and three Power Jets engineers. That was how collaboration with the United States started. With this help they have built up a gas turbine industry of their own, and their technicians and ours have visited one another and exchanged information with the greatest frankness.

Since the performance of the Whittle engine in the early days of the war showed the great possibilities of the jet propulsion gas turbine, the development has had the full support of the Government. The work done in the Power Jets company, in the Royal Aircraft Establishment and in the companies who were later brought in, has been encouraged and co-ordinated by the Ministry of Aircraft Production. The confidence of the Government's advisers in the gas turbine has indeed been thoroughly justified, and the considerable sums of money expended have produced, in the technical sense, enormous dividends.

Towards the end of 1943, the scope and character of the gas turbine development was such that the Government decided that it must have its own national organisation for the advancement of knowledge of the gas turbine on behalf of British industry and for the fighting Services. The Power Jets team and the Royal Aircraft Establishment team of gas turbine engineers were accordingly placed under the direction of a new company known

as Power Jets (Research and Development) Limited. The duties of this Government owned company are to conduct research and development in close collaboration with the private companies concerned with gas turbine work. These national activities require large experimental testing plant and a useful proportion of this plant is in operation. With this equipment at the service of British industry, further great technical steps forward will be achieved.

The development of the gas turbine, like the discovery and development of radio location, is one of the major technical achievements of modern times. It is vital to the future of our engineering industry that we maintain the lead in this new development which our pioneers have given us. I have every confidence that we shall maintain the lead, because I know so well the quality of the engineers, manufacturers and scientists who have brought us already so far along the road.