James R. Killian, Jr.:
University Research and
National Priorities

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The University in Today's World
Graduate Engineers—Who Needs Them?
Engineering and Society/Women in Science

Technology Review

UNIVERSITY & SOCIETY

Allegheny Ludlum Steel Corporation is pleased to introduce
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Titanium Metals Corporation is pleased to introduce
True Temper Corporation is pleased to introduce
The Wallingford Steel Company is pleased to introduce

our new family name

Allegheny Ludlum Industries

Our new name tells you we're more than the top-ranking specialist in one basic industry. The world's leading producer of specialty steels did bring us all together. But we're actually a group of companies in one—different yet interrelated companies working together for mutual and collective advantages in serving growing markets. For all of us, Allegheny Ludlum Industries, Inc. represents a new corporate identity . . . a new organizational structure to coordinate activities, technologies, facilities and products. Now, don't get us wrong. Allegheny Ludlum Steel Corporation still exists. And it remains the world leader in the creation and production of stainless steels, electrical and magnetic steels, tool and die materials, valve steels, high-temperature super alloys, and other sophisticated materials for advanced technologies. But now, it has become a part of something bigger. Something big enough to be called Allegheny Ludlum Industries.

New markets

It all began back when Allegheny Ludlum Steel began to expand into technologically related fields. First it was tungsten carbides. Then magnetic specialties. Then electronic components, and high alloy materials rolled to very thin gages. Then it was powder metallurgy and precision tools.

Before long True Temper Corporation joined the family, moving us into the consumer products field with garden and hand tools, fishing gear, golf club shafts, sleds, and other sporting equipment. From there it was a short step into outdoor power equipment, produced by our newest, Jacobsen Manufacturing Company.

New organization

And here we all are today, under the banner of Allegheny Ludlum Industries. Logically, our member companies fall into four major groups, according to types of products and markets served. They are: (1) The Steelmaking and Specialty Metals Group, (2) The Industrial Products Group, (3) The Magnetic and Electronic Materials Group, and (4) The Consumer Products Group. In addition, we have a 50% interest in Titanium Metals Corporation of America, and in the Belgian steelmaking firm, Allegheny-Longdoz.

Central to all groups is a research and development center at Natrona Heights, Pennsylvania. This excellent facility will serve to cross fertilize research and development throughout the entire organization, producing maximum technological advancement for all.

New directions

Where is Allegheny Ludlum Industries going? Our sales mix gives a good indication. Seven years ago about 95% of our sales were in specialty steels, and we were operating basically as a specialty steel company. Today, while we are still number one in that field, 68% of sales are in specialty materials, the rest being in some of the other most promising growth markets of the seventies.

When you have a group of growth-minded companies, all in growing fields, all with interrelated technologies and research projects, and all coordinated by a central, growth-minded organization, there is only one logical forecast. Allegheny Ludlum Industries, Inc. is going where tomorrow is.

Allegheny Ludlum Industries

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The First Line

In the softness of the spring twilight, with dinghies dotting the Charles River and sunset light on the Boston skyline, it is easy to propose that everything is the same as it always was in the grey edifice which surrounds M.I.T.'s Great Court. Alumni returning for reunions in June found the surroundings familiar, their dreams of the "good old days" little interrupted. Yet changes there are, and it is my purpose here to suggest that changes —long-sought, fundamental for the nation as for one institution—stand behind the apparently superficial mutations evident throughout M.I.T.

What incongruities may have given M.I.T.'s spring visitors pause?

◇ A campus patrolman stands patiently in the corridor near the office of the President.
◇ Art (and some tasteless graffiti, as well) decorates the once-grey corridors (*see page 19*), and a refreshment stand greets visitors in the main rotunda.
◇ Because they have persistently sought to disrupt the process of campus decision making and discipline, two young people formerly registered as M.I.T. students have been declared unwelcome on the campus; and the Staff-Administration Committee continues to deliberate on how the Institute may respond without abridging faculty freedoms in the cases of two members of the teaching staff whose actions have been similarly (if not so crudely) offensive.
◇ *Voo Doo*, M.I.T.'s unhumorous collegiate humor magazine, has vanished from the scene; so have the fall, winter, and spring "party weekends."
◇ Campus vandalism is increasing; windows have been "trashed," slogans painted on buildings.
◇ Two M.I.T. classrooms have been turned over to students and staff as headquarters for political action, where visitors may retrieve voting records and interview reports from the computer, pick up political literature, and register their interest in future political action.
◇ M.I.T. has brought civil complaints, and members of the faculty have been in court to testify, against students.
◇ Faculty meetings have suddenly become emotionally charged "town forums" for the community, a place where—despite an abundance of predictable rhetoric—hard-fought issues have come to decisions.

How does this recital of change at M.I.T. yield a judgment of fundamental and positive mutation in the Institute community? Is it not simply, as one member of the faculty has complained, a series of distractions which keep people from their real work, a preoccupation with the irrational or trivial?

It is not. For decades past its administration and faculty have proposed the Institute's obligations to assure the social usefulness of the technology which it brings forth. The lesson is beginning to find its object; the confusion of incongruous change which lies hidden behind M.I.T.'s unchanging grey walls is in fact the Brownian motion of a community at last confronting new issues and doing new things. It is not at all a question of President Nixon's "bums blowing up campuses." The issue is far better put by Walter A. Rosenblith, M.I.T.'s Associate Provost: "No longer is it enough to give a one-time proof, to develop a device, to be analytically wise and action blind. . . . We must follow our work into the real world, live with our successes and make them truly serve mankind."

We are trying to learn how.—J.M.

Volume 72

This issue completes *Technology Review*'s 72nd volume; Volume 73 will open with an issue dated October/November, 1970, due off the presses during the last week of September.

An index to Volume 72 of *Technology Review* is now in preparation and should be available late in the calendar year. Copies will be supplied without cost to library subscribers to the *Review* and to others upon request. Meanwhile, long-postponed indices to Volumes 70 and 71 are nearing completion, and requests will be filled late this summer.

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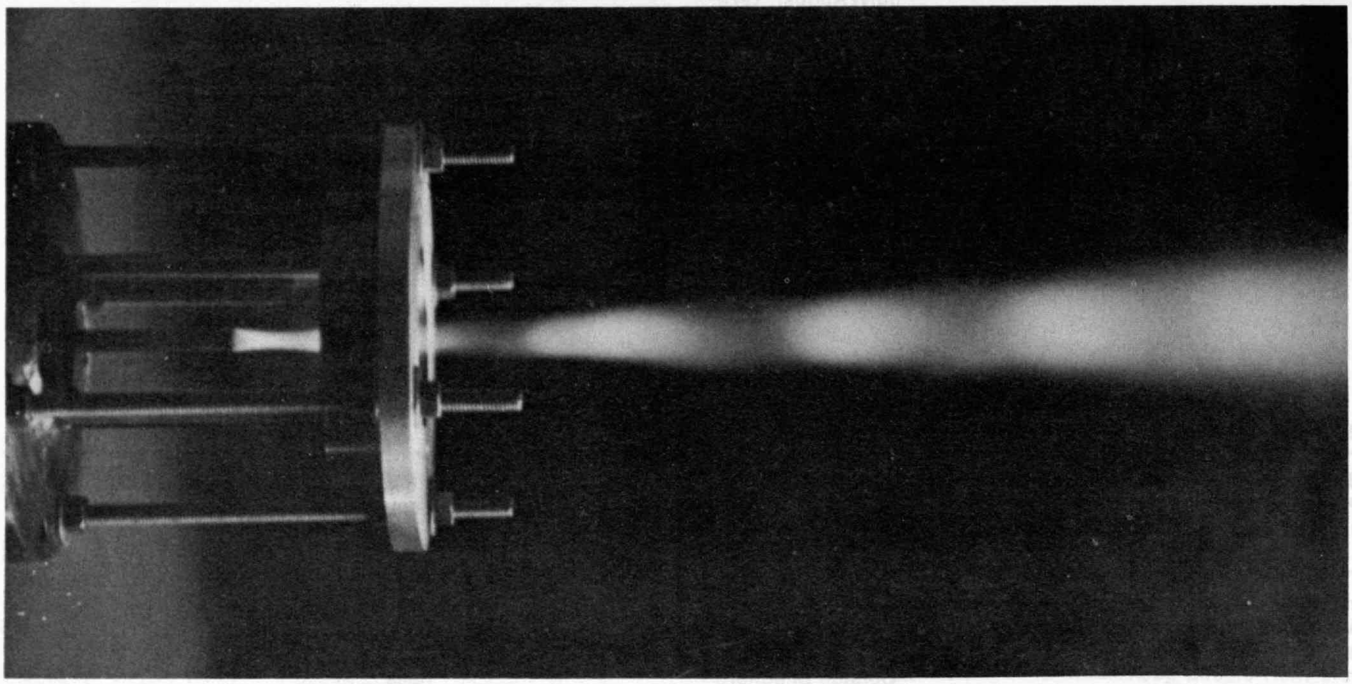

Variation of Flame Intensity with Ignitor Pilot Power and Stagnation Temperature in Mach 2 Stream

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The photograph above was taken during experiments performed under contract for the United States Air Force. For several years, NREC has been egaged in theoretical and experimental studies of pilot-flame ignition and flame spreading in scramjet combustors operating at flight speeds below the spontaneous ignition regime. Further studies are directed toward the mixing, ignition and combustion of high-temperature fuel-rich jets in a supersonic, ducted air stream, in order to provide improved techniques for the performance analysis of gas-generator-fueled ramjet and scramjet combustors.

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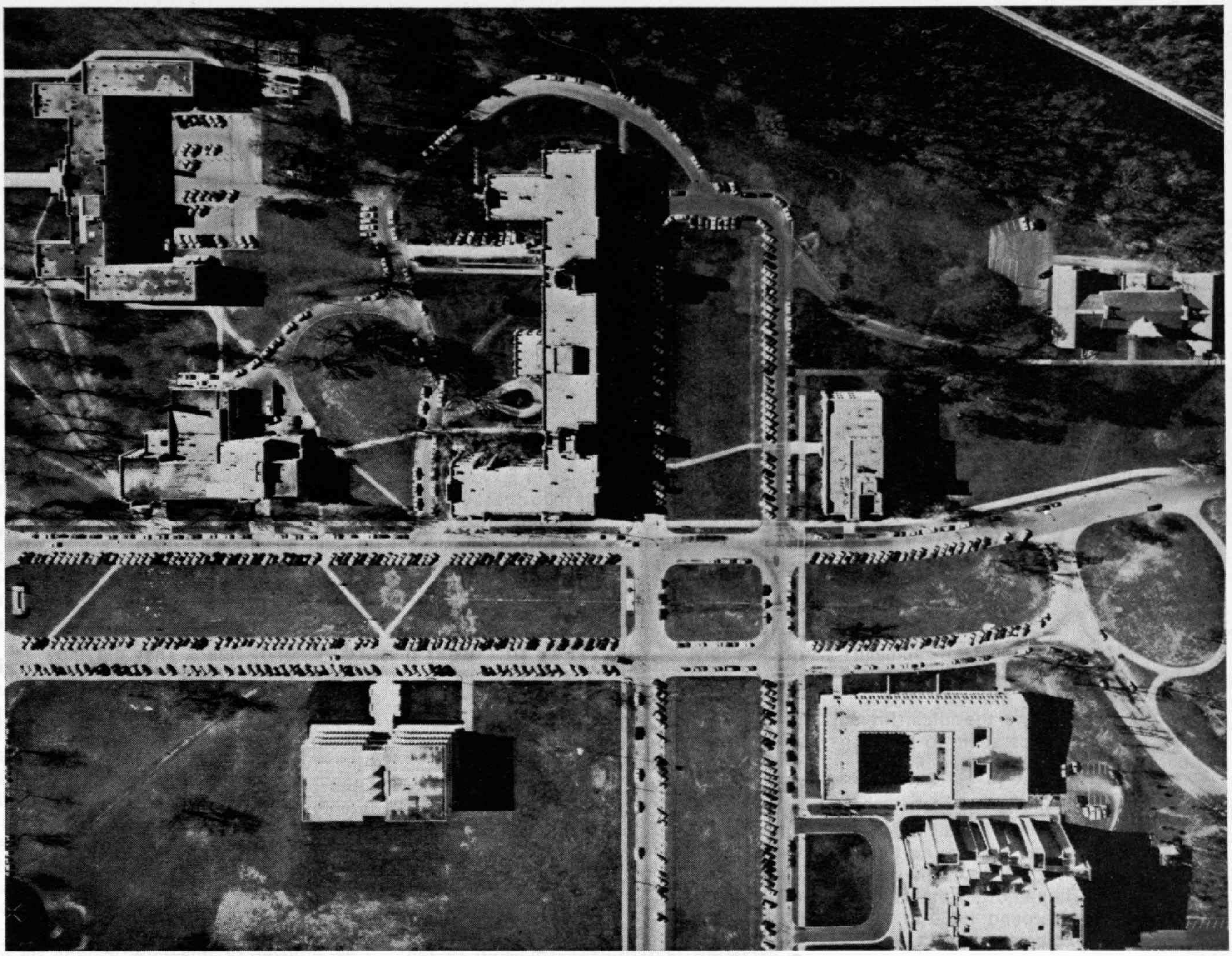

Science Review
Robert C. Cowen

Aquanauts are trying to prove or disprove the existence of a human "depth barrier." Can biological machinery that evolved "in a soft embrace that was never far from 15 lbs./in.^{2}" survive and work safely 1,500 ft. below the surface of the sea?

On Human Systems under Pressure

In their passion to "conquer" the sea, men put their bodies under pressures that would crush some older military submarines. They keep trying to see how deeply they can pursue the aquanaut game, how deeply they can live and work without the protective isolation of diving capsules.

Experts have swung between optimism and pessimism on this question of "ultimate" depth. Now a British "dry-diving" experiment and the latest French venture in aquanautics seem to be pushing back the uncertainty a little bit.

Last March, Dr. Peter Brian Bennett's team at the Royal Navy Physiological Laboratory sent three men to the equivalent of 1,500 ft. for 12 hours in a pressure chamber. They showed that a depth barrier suspected around 1,000 to 1,200 ft. by some physiologists doesn't seem to exist.

Meanwhile, at Marseilles, French aquanauts are getting ready to carry out practice work assignments at 250 m. (825 ft.) in September. Three of them have already run through an eight-day rehearsal in a pressure chamber, adapting well to the "deepest" long-duration "undersea" living yet. Men have gone to greater pressure in tests like that of Dr. Bennett. It's something else again to get on with living and working with the conditions of depth as merely the background for your activities.

A few years ago, such an authority as American Navy Captain George F. Bond, who pioneered the theory of aquanaut diving, was saying he knew of no basic physiological reason to expect any particular depth barrier for man. Nevertheless, there have been some disquieting experiments. Monkeys and other animals under pressures equal to 700-m. depths and deeper have gone into convulsions and often have died. In much shallower tests, men have developed tremors, nausea, and vertigo.

Rising Pressures and Falling Tolerances
One of the first things physiologists suspect is the poisonous or narcotic effect of breathing mixtures. Divers use oxygen diluted by an inert gas such as nitrogen or helium. As pressure rises, great care has to be taken to see that men get the right amount of oxygen. A little too much, under high pressure with increased carbon dioxide present to accentuate the effect, and oxygen becomes a brain poison. Yet too little oxygen would quickly starve the brain. As pressure increases, the margin between too little and too much narrows appreciably.

Then too, the carrier gas can cause problems. Dissolving in the blood under pressure, it can cause a kind of drunkenness or even knock a diver out. Divers going beyond relatively shallow depths use the less narcotic helium rather than nitrogen for this reason alone. They also like helium because, with its low molecular weight, it's much easier to breathe under high pressure than is a heavy gas like nitrogen.

Beyond the toxic effect of gases, there's the uncertainty about possible unknown effects of pressure itself on the human system. The breathing gas in his lungs, equalized to ambient pressure, prevents the diver from being crudely crushed. But may there not be subtle pressure effects beyond a certain point? Some aquanauts have, for example, reported their joints were so compressed they squeaked and crackled. They felt, as one put it, as though they had an "absence of joint juice."

Is There a True "Depth Barrier"?
However, the evidence for any kind of depth barrier has been fuzzy. Adverse reactions in men and animals have often been transient. Individuals have recovered and appeared to adapt well to the very pressure where symptoms at first set in.

In 1968, Duke University's Ralph Brauer encountered what he thought might be a depth barrier for oxygen-helium diving around 1,000 to 1,200 ft. He was "diving" in a pressure chamber of the Compagnie Maritime d'Expertises (COMEX) with engineer René Veyrunes. They experienced what looked to be a kind of helium narcosis. Yet experts such as Captain Bond were skeptical, thinking that Brauer had merely pressurized too fast rather than run into a true depth effect. So there has been much interest in an experiment to take men well beyond 1,500 ft. such as Dr. Bennett ran last March.

He built up pressure on his two divers gradually over several days. They spent 24 hours each at equivalent depths of 600, 1,000, and 1,300 ft. Then, after an hour at 1,400 ft., they "descended" to 1,500 ft. for 12 hours. They did show some of the changes in brain activity and other symptoms reported earlier. But these were transient. They recovered and carried through the test with no difficulty. If men are going to run into a depth barrier in their effort to work directly within the sea, it may well lie below 1,500 ft.

Encouraging as this result is, physiologists still grope with the unknown at even lesser depths. R. Naquet of the Institut de Neurophysiologie et Psychophysiologie at Marseilles warns that just being able to take men safely to 1,500-ft. pressures in a chamber isn't enough. He works both with aquanauts and with monkeys. The real problem, he says, is that no one knows what's causing the tremors—or in monkeys the convulsions—and other symptoms. Is it oxygen poisoning or deficiency, helium narcosis, some other subtle pressure effect? At this point, M. Naquet says, "all you can do is put a question mark. It's useless to try to draw conclusions."

And until the nature of the effects is known, men cannot feel confident about really deep diving—even though the disquieting symptoms may prove transitory in tests. Practical divers may feel that, unless pressure symptoms are incapaciting, especially if they are transitory, the symptoms can be ignored and they can get on with the job. Physiologists know that even mild, transitory symptoms may warn of subtle dangers when men try to force the human mechanism to function in such an alien environment.

Here is the kind of physiological pioneering you encounter in the space program. In space, weightlessness is a constant and alien factor. Yet astronauts tend to ignore the occasional dizziness or more subtle phenomena such as calcium loss which they have experienced because they have not been seriously inconvenienced. Space physiologists still consider prolonged weightlessness one of their great unknowns. They have seen enough to know that they don't really know how the human system adapts to lack of gravity in the long run.

Living and Working in the Sea

Just as weightlessness was no problem in flights to the moon, though, so diving physiologists don't expect pressure, as such, to inhibit aquanauts in France's Janus 2 project for experimental work at 825 ft. Sponsored by the Centre National d'Exploitation des Océans, Janus 2 is part of France's long-term strategy to exploit mineral resources of the continental shelf. Daniel Coulmy, who heads CNEXO's Programs Division, says shelf exploitation is a priority item for his agency. He wants to develop, as quickly as possible, the capability to have aquanauts operate anywhere on the shelf and even beyond it. Ability to work at 825 ft. would go a long way toward that goal.

When the three Janus aquanauts emerged from an eight-day rehearsal in pressure chambers, they told their press conference they had been comfortable and happy. And they had demonstrated an ability to work at significantly greater pressure than that under which they lived, a capacity that adds much to an aquanaut's value. In September, six aquanauts will live under the pressure equivalent of 200-m. depths in a shipboard pressure chamber. They will share two daily four-hour work shifts at 250 m., descending to the job by diving bell. In the rehearsal, three aquanauts simulated this by living at 200-m. pressure and twice daily transferring to 250-m. pressure for practice work with such things as oil rig equipment. They went between the two pressure levels freely, without the need for decompression.

Aquanauts have an advantage over ordinary divers in working more efficiently. A diver who returns to the surface every work shift must often spend much of the shift slowly decompressing to normal pressure to avoid the bends, the bubbling up of gas dissolved in his tissues under high pressure. An aquanaut retreats to a pressurized house, spending his full work time on the job and decompressing just once when the entire job is finished. Now the Janus aquanauts have demonstrated that aquanauts can work substantially deeper than they live without decompression when returning to the intermediate depth. And when they return to the surface, they undergo only the decompression appropriate for their living depth, rather than their working depth. This adds to their efficiency. It gives them greater flexibility in working depth.

Dr. Xavier Fructus, COMEX physiologist, considers this one of the most important results of the Janus 2 project so far. He emphasizes, though, that the Janus technique still has to be proved in the sea. There, the aquanauts face a greater physiological challenge than just adapting to pressure. Disorienting darkness can induce anxiety that in turn affects their adaptation. Numbing cold can sap strength. Since helium in the breathing mixture is an efficient heat remover, aquanauts lose much body heat in exhaling. This adds to the water's chill. Aquanaut pioneer Jacques-Yves Cousteau has compared the experience to standing naked in the Arctic.

Aquanauts have tried to overcome this by using heated suits. In some uses, heated water is passed into their wetsuits by special tubing. However, Dr. Fructus says this only partly solves the problem. The men still lose much heat through breathing. Warming the helium also helps. Here you have to take care to warm to body temperature and no higher, for you could then overheat the diver.

Problems for Technology

Keeping warm, holding down humidity and carbon dioxide accumulation in aquanaut living quarters, and other comfort factors are really technological problems, not physiological. And engineers still have to solve them satisfactorily. In fact, Dr. Fructus says that, strictly speaking, the May rehearsal has already shown that men's bodies can adapt to Janus 2 conditions. It's the technology that needs perfecting.

This may be true also of the tremors and other discomforts men have experienced on the deeper experimental dives. If they are due to oxygen poisoning or starvation, closer control can be established over the breathing mixture. If they are due to helium narcosis, perhaps better techniques for building up to maximum pressure would alleviate them. In the long run, says Britain's Dr. Bennett, the depth limit on diving may be set by the sheer effects of pressure as pressure, not by secondary influences of breathing gases or cold. Thus the real challenge diving physiologists face is to define the ability to withstand pressure of biological machinery that evolved in a soft embrace that was never far from 15 lbs./in.^{2}.

Robert C. Cowen, who contributes regularly to Technology Review, *is Science Editor of the* Christian Science Monitor. *He is currently stationed in London and has recently visited many science activities in France.*

European Report
Colston Shepherd

Europe's co-operative air bus project—the A-300B—now seems likely to share the field with a British aircraft, the B.A.C. 3-11. Together, they offer an enlarged choice to U.S. short-haul operators.

Europe's Air Bus Projects

American observers have lately been remarking that Europe has nothing in the airliner class on the stocks except the short-haul air bus. The whole of the rest of the airliner market is monopolized by the United States. They may be disposed to ask why Europe's relatively small enterprise on the edge of the market should be allowed to go unchallenged. Surveys show that there should be a demand for 600 to 700 short-haul liners in the present decade and for at least 1,000 in the long run.

Boeing was tempted. The difficulty of financing the development in present circumstances seems to have checked that impulse. Lockheed likewise had thoughts in the same direction but turned instead to the long-range version of the 1011. Douglas is fully occupied in competing with the 747. In any event, American constructors appear to shy away from the big two-engine liner. Because they know they must cater for the cross-continental services with a range of 3,000 miles, they are forced to opt for the three-engine layout and they aim at making it serve for the shorter ranges as well.

The curious thing is that quite a big proportion of the United States' domestic traffic consists of passengers who travel less than 1,000 miles. Three years ago this stood at 43 per cent and it has been increasing. It now stands at 60 per cent. Europe's traffic in this category is a much bigger fraction of the whole. It stood last year at 90 per cent. The need in Europe for a short-haul bus is thus much greater than for the medium-range class which America has on offer. A maximum range of 2,000 miles with full payload will be ample, but at the same time the operational economy associated with the big unit is desirable. The formula for Europe therefore is the wide body and two engines.

There is no pretense that this can have the same payload capacity as the three-engine bus. Whereas the 1011 can be provided with 330 seats, the limit in the European bus is 270. As the European bus is said to have a direct operation cost one-third less than the three-engine type, it must be presumed to be a more profitable vehicle for European purposes. The claim made for the 1011 is that it remains "fully competitive" down to a range of 500 miles; what Europe wants is a liner that will show a good profit at average load factors down to a range of 350 miles.

The Three-Nation Airbus

European operators could undoubtedly have made do with one of the wide-body types from the United States though it would not have been tailor-made for their routes. If they had done that, they would have left the aircraft industry in Europe without a single airliner project. Only feeder-liners and executive and private aircraft would have remained to keep active the big design teams which have hitherto been concerned with commercial aircraft. There is plenty of work on the military side, and at present there is a brisk export business. British exports, for instance, stand at more than $750 million a year, made up of both military and commercial aircraft products. Governments recognized the value of the industry in maintaining the balance of trade and this had an influence in the decision to provide the European operators with a bus designed to meet requirements. The result was the cooperative project now known as the A-300B.

That decision was encouraged by the knowledge that a special version of a new engine of European design could be made available and that it was so highly approved as to be chosen for the 1011. This engine, the Rolls-Royce RB 211, offered lightness, fuel economy, and relative quietness—characteristics derived from the use of plastic materials, where appropriate, and from providing separate drives for the fan and the two compressors so that each can turn at optimum rates in all operational circumstances. It was also designed in the modern fashion in self-contained sections to allow for easy replacements without having to change the whole engine when a fault occurs.

In 1967, Britain, France, and Germany agreed to proceed jointly with the project, and design work began on the basis of individual work done by Hawker Siddeley in England and Sud Aviation in France. In only one respect was there an attempt to break new ground and that concerned the wing.

Hawker Siddeley has been working for some years on a means of improving lift by extending it farther aft on the upper surface of the wing. This they achieved by what they called "undercutting" the lower surface. In America this was called the "peaky wing" and it has latterly been taken up by N.A.S.A. and developed to the point at which it promises, under the title of the "supercritical wing," either to allow cruising at Mach I or to yield a marked saving in structure weight at lower speeds.

Apart from this departure, the European bus is a conventional type in the wide body style with its engines slung on pylons under the wing and an orthodox tail. That is to say, it avoids the high tailplanes and elevators which, at pronounced angles of attack, can lead to the deep stall and make essential the fitting of automatic stick-pushers to depress the nose in critical situations. Its wing is swept back 28°, and the "peaky wing" idea has been applied not to increase cruising speed but to permit a thicker wing form to be used, with a saving of 2,500 lb. in structure weight. Slats and flaps give good take-off, climb, and approach performance. For example, the approach speed at maximum landing weight is only 130 knots (about 150 m.p.h.) This is associated with a maximum cruising speed of 570 m.p.h. and a normal range of 1,400 miles. The passenger capacity is 261.

When, last year, the governments came to the point of guaranteeing development costs, Britain found herself faced with the prospect of having to contribute some 240 million dollars, or nearly twice as much as she had expected to have to find two years earlier, and she backed out. Hawker Siddeley took over, as an ordinary commercial risk, responsibility for the construction of the wing, and the rest of the work will be shared between two consortiums in France and Germany. In breaking away from this piece of collaboration, the British Government knew that an alternative design for a short-haul air bus had been prepared and was ready for development if enough firm orders could be obtained. In this instance, there would be no question of guarantee except in the form of a loan to the constructor.