The Type "21" U-Boat

(By Our Naval Correspondent)

No. I

IT is perhaps inevitable that a nation in which everything has been for long keyed to a single aim and a single arm, should be able to produce something better in this specialised category than the experts of a nation in which research, design, and construction have necessarily been spread over a wide field. The contrast between Germany and Great Britain is one of highly specialised effort on the one hand, as against a potential which has had to be used sparingly in certain fields in order that there should be enough of everything. Nobody can visit the German ports without realising that a very high proportion of the whole war potential of the country was devoted to the production of U-boats, and that designers and constructors had been given a far greater degree of freedom than has ever been accorded to them on this side of the North Sea. In Germany, U-boats were not only "priority one"—they held nearly all the priorities, and the regimentation required of constructors of prefabricated parts was more than balanced by the very free hand given to the designers. One can hardly imagine a U-boat designer, having perfected some new "gadget" which had been proved to be of value during sea trials, having to pursue the matter through various Government compartments and compete with the production of all manner of other goods, both in the material and in the labour market.

It is therefore no reflection upon British designers of submarines to say that, in some directions, German submarine design and construction, as discovered and studied by British experts after the surrender of Germany, is ahead of that of Great Britain. One must observe the qualifying phrase "in some directions," and avoid the pitfall of thinking that everything that is novel is necessarily good.

In the type "21" U-boat, for instance, which was the largest and the latest in production, there are many things which make the mouths of British submarine officers water. On the other hand, there are many British submarine officers who would criticise the design with some justice on certain grounds—notably that the offensive armament is comparatively small for the size of the craft.

There is no doubt, however, that we have much to learn from the captured U-boats. It may be a hard saying, but in the forcing house of war German designers have solved problems which we have long considered insoluble. It is curious, too, to notice that the German solutions are so frequently produced by simplicity and a ruthless reversion to first principles.

Let us consider, for instance, the "schnorkel." The great "secret" about this device turned out on examination to be nothing more than the adaptation of a principle which is brought into use by everybody, every time they pull a lavatory plug! Consider also the question of the phenomenal submerged speed of this very large type "21" U-boat. It is obvious that the Germans have argued the matter something like this:—If, as is common submarine practice, one can greatly increase the submerged speed by grouping the batteries, one can get an even higher speed range by grouping the batteries yet again. But in the usual submarine this cannot be done, because of the limited number of batteries. Then why not have more batteries?

It is all delightfully simple, and yet a combination of these innovations has produced an underwater craft which is, quite literally, revolutionary in many points of design and of performance.

The writer recently had the opportunity of spending several hours in making a detailed examination of one of the type "21" U-boats. This was the latest ocean-going form (apart from experimental craft) which was in production in Germany, and only a few of them were in commission at the time of the surrender. Only one had completed an extended cruise, which had been in the nature of a trial of the new type. This was "U. 3008," which was the vessel examined. The Germans obviously thought very highly of this type, for they had ordered no less than 200 of them.

This U-boat had some features which were quite revolutionary in submarine practice, and a performance which was regarded as legendary until it had been established beyond possibility of doubt.

Before giving any detailed description of this boat and her fittings it may be as well to outline some of the facts which seemed so astonishing to those accustomed to the more orthodox submarine design and compare them with the latest available information regarding our own submarines.

Speed, Depth, and Endurance

The type "21" U-boat is a vessel of approximately 1600 tons displacement when on the surface. Her speed on the surface, even with a supercharger, is slow by comparison with the equivalent British and American types, and she is not fitted with a gun of a size which would make her capable of engaging a ship. Neither of these facts is surprising, for there is no doubt that the type "21" U-boat is not designed for surface work. She was not even expected to proceed on the surface when going to and from her operational area. She is, in fact, a submarine in the true sense of the word, rather than a submersible.

This submarine was not designed to come to the surface except when entering or leaving harbour, or, of course, if temporary outside repairs had to be done at sea. In the normal course of events "U. 3008" could remain at sea for five months without ever coming to the surface and the German officers averred that, if every nook and cranny in the submarine were packed with provisions, the submarine would be able to remain at sea—submerged all the time, if necessary—for as long as nine months. This, however, had not been done, and the records of U-boats which have been surrendered do not contain any reference to a U-boat remaining submerged for more than seventy days.

The U-boats of this type were actually tested to a depth of 900ft., whereas British submarines are tested to 200ft. and 300ft. according to type. In emergency, the type "21" U-boat is capable of a submerged speed of 16 knots, although, of course, only for a short time. When one considers that the fastest underwater speed of the normal submarine is in the nature of 8 or 9 knots, one begins to appreciate that the figure of 16 knots for the full speed when submerged of a vessel of more than 1600 tons is really amazing.

It is true that in the last war, when we decided to set submarines to catch the U-boats, we built a small "R" class which had a designed speed below water of 15 knots, but these were small boats and the increase in submerged speed was only achieved at the expense of nearly all the surface speed and the fitting of enormous batteries which took an unconscionable time to charge.

The full speed of 16 knots submerged, can of course, only be maintained for a very few minutes, but those minutes might well enable the submarine to evade its hunters. The very fast submerged speed is, in fact, more of a defensive than an offensive characteristic, although it would, of course, be of the utmost use on occasions when attacking, particularly if the target ship was sighted late and passing a long way off or altered course away during the attack.

Acceleration

It is rather extraordinary that in this type of U-boat it is apparently possible to accelerate quickly to this full speed and then to decelerate again without having undue trouble with the depth keeping. When a submerged submarine suddenly increases her speed there is an inevitable tendency for the bows to rise. The effect of this angle up by the bow is accentuated by the increasing speed and the submarine has a dangerous tendency to break surface out of control, particularly in a large and long vessel. This tendency must, in the nature of things, be common to all types of submarines and it can only be reduced by design—never eradicated. It is due to the fact that a submarine must have a conning tower and bridge. In other words, there must always be an excrescence, which, on sudden acceleration, leads to an increased water pressure well above the line of thrust of the screws, so that there is a marked upward turning moment.

In any submarine the hydroplanes have to be given "dive angle" on a sudden increase of speed when submerged. It is probable that in U-boats of this type, the hydroplanes are put to "hard to dive" as the acceleration begins to take effect. Were this not done there is no doubt that a large submarine which increased its submerged speed suddenly from 4 or 5 knots to 16 knots would inevitably shoot to the surface out of control and with a very big angle up by the bow. One wonders whether some of the tales one has heard of U-boats breaking surface at astonishing angles up by the bow have not had their origin in the unexpectedly high rate of submerged acceleration of which many of them were capable.

This tendency to break surface on acceleration opens up another train of thought. The effect of hydroplanes and of an angle on a submarine increases rapidly with an increase in the speed of the vessel. If the hydroplanes have to be put to "hard to dive" and an angle down by the bow put on the submarine as the order to increase to full speed is given it is quite possible that these would more than override the upward moment. They certainly would override it at some point between the beginning and the end of the period of acceleration, the actual moment of override being dependent upon the hull and conning tower form and the design of the hydroplanes. The moment this override comes into play the angle on the submarine, the angle and effect of the hydroplanes, and the increase of speed will all tend to drive the submarine down, and in a long submarine it is almost certain that control would be lost for a time. Is it not more than likely that appreciation of this danger—a danger which led to disaster in more than one of the big fast

British " K " class submarines—is the reason for testing the hulls of the big U-boats to the great depth of 900ft.?

The ability to dive safely to great depth has, of course, other advantages. There have been a great many occasions during the war when we have heard of U-boats being " blown to the surface " by depth charges. There have probably been occasions on which this has been due to the emergency blowing of the submarine's tanks in a desire to reach the surface and save life after the vessel has received crippling damage. The words " blown to the surface by depth charge attack " which have appeared in several official announcements, however, definitely suggest that the depth charges have exploded beneath the submarine and that their explosion has forced the submarine up until it has broken surface. This is perfectly feasible, not to say desirable. Moreover, there is no denying that the effect of a depth charge beneath a submarine, where the sea pressure is already large and where the space for the explosion between the hull and the sea bed may be limited, is apt to be greater—and certainly more satisfying to the attackers—than the explosion of depth charges above the vessel. It is therefore quite possible that the tested depth of the new U-boats has a definite relationship with the German information of the deep depth settings normally used on our depth charges.

Some of the capabilities of the U-boats of this type are almost reminiscent of the fancies of Jules Verne—nine months below the surface, capable of 16 knots under water in emergency, and safe at a depth of 900ft.

These were qualifications so high that they would have been deemed impossible a short time ago. The Germans were forced to make them possible and workable, and they were forced to integrate other factors in their design and building in order that they should fit in with the general conception of the possibility of these " super-U-boats."

Habitability

German designers and builders had combined to produce a U-boat which was capable of keeping at sea for a very long time. There was no doubt that German systems of training young men and officers would produce efficient personnel, but neither fanaticism nor short-time training could produce a personnel which could be trusted below the surface for several months on end without risk of revolt against the discomfort and lack of privacy which has always been considered the price of service in submarines in all navies.

If a submarine is designed to remain at sea—and submerged—for very long periods, one of the primary considerations must be habitability. If men have to live and work in a machine, there is no sense in producing a perfect machine if the men cannot live and work in it with the same human endurance as the endurance of the machine.

Examination of the type " 21 " U-boat shows that the Germans were fully aware of this truth. In parenthesis it may be remarked that this solicitude for the comfort and well-being of the personnel was a direct antithesis of that in the surface ships of the German Navy of the last war, in which living conditions for the crews were reduced to the lowest compatible with short periods at sea and long periods in harbour. It was this German philosophy of living conditions which allowed them to subdivide their ships to an extent which reduced enormously their chances of being sunk, but at the same time reduced their seagoing efficiency, except for sorties of short duration. One remembers that this was one of the factors which limited the operations of the High Seas Fleet in the last war.

In the type " 21 " U-boat there is no necessity for any members of the crew to work on what British submarine personnel used to call " the hot bunk principle "—that is, turning in to the bunk of the man who has relieved one on watch. In " U. 3008 " there is a comfortable sprung bunk for every member of the crew—and every bunk is provided with a fitted mattress. Moreover, all the living spaces are enclosed in light fire-proofed wooden bulkheads and are on either side of a central gangway running right through the submarine and deviating from the centre line only in the control room, where it has to skirt the casing of the big power-operated periscope. Officers and men therefore have a degree of privacy far beyond that usual in submarines, where a " mess " may also be a gangway, and sometimes even a table set up in the torpedo-working compartment, so that it is " ' fish ' for breakfast, ' fish ' for dinner, ' fish ' for supper, ' fish ' for every——meal ! "

There is little doubt that this system of enclosed messes and a clear central gangway makes for efficiency as well as comfort, for it does away with the necessity for men slinging hammocks or sleeping on mess tables or on the deck—practices which are apt to turn a gangway into a complicated assault course in emergency.

Hull Section

The type " 21 " U-boat has a novel and peculiar hull section, which also increases the spaciousness and habitability of the submarine. This hull section is called " figure of eight," which almost exactly describes it. The section amidships consists of the usual circular section pressure hull, with beneath it another smaller circular section pressure hull. These two circular section hulls are not separate, and, in effect, they form part of the same " figure of eight " sectioned pressure hull. Each part is not only immensely strong in itself; they are joined by very strong plating which is worked on a curve so that there is no weakness at the junction of the two parts of the hull.

This peculiar hull form increases stability, and also very considerably increases the space within the upper part of the pressure hull, which contains the living quarters. This is because the electric batteries, the big refrigerated store rooms, the internal ballast tanks for trimming purposes, and a certain amount of the auxiliary machinery have been banished to the lower part of the pressure hull section. The result is that the whole diameter of the upper part of the hull, except where it is cut off by the flat deck across the junction of the two parts, is available space. In normal submarine practice rather more than one-third of the hull section is taken up by the batteries and internal ballast tanks.

In the German submarines of this type the space within the pressure hull is still further increased by the simple expedient of placing the frames outside instead of inside the plating.

This method of construction adds, in effect, some 10in. to the useful diameter of the inside of the pressure hull. At the same time it simplifies to a very great degree the fitting of pipes, electric cables, and fittings. This simplification means, of course, that less space is taken up in the actual fitting of the essential requirements, as well as the refinements, and it makes the fitting of built-in furniture a simple matter, instead of an art which often appears to have been practised by a Torquemada with an apostle of discomfort at his elbow.

Technically, of course, a hull with the frames fitted externally is not as strong as a hull with internal frames. In the German design, however, this is more than made up for by the use of larger and stronger frames. When all is said and done, the size of an internal frame is strictly limited by the amount of space which can be allotted to it within the submarine's hull—a consideration which does not arise in the case of external frames. Any weakness in this design is therefore more than compensated by the fitting of larger and stronger frames, for the size of these external frames is immaterial. The frames in this type of U-boat are, in fact, nearly twice the size of those in the average British submarine.

The plating of the pressure hull, comprising both the upper and lower sections, has a minimum thickness of 1·1in., and this is increased to about 1½in. in certain places where weakness would otherwise be caused by penetrations of the plating, such as around the hatches.

The Outer Skin

Built round the " figure of eight " pressure hull and over the external framing of the hull is the outer skin of the submarine, which gives the vessel a very fine streamlined form. Between the outer hull and the pressure hull are the main ballast tanks and the compensated fuel tanks, in both of which the internal pressure is automatically equalised with the sea pressure when diving, so that the outer hull can safely be built of light plating. This, of course, is normal submarine practice.

It is interesting to note that in this type of U-boat there are no Kingston valves at the bottom of the main ballast tanks. These are open to the sea at the bottom, so that the submarine when on the surface is " riding on the vents "—that is, prevented from losing buoyancy by the air lock trapped and held in the main ballast tanks by the vents. This system, which is by no means new, has the advantage that only one valve for each tank has to be opened in order to submerge, even if the submarine has not been previously brought to a condition of instant readiness for diving. The vents are, of course, operated by telemotor from a panel of levers in the control room.

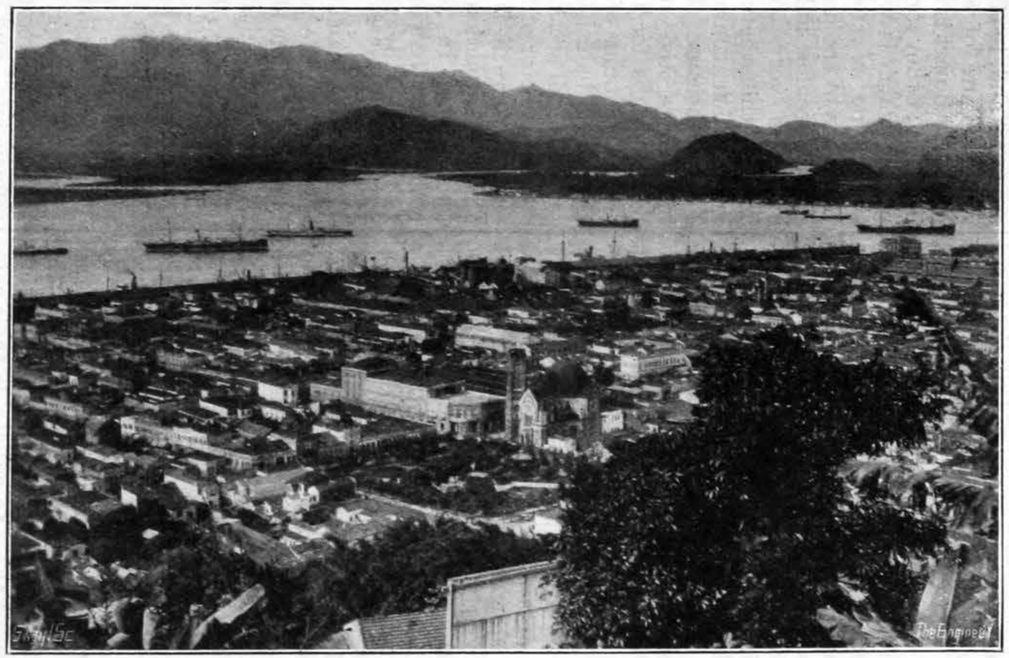
While considering the streamlining of this U-boat it is of interest that the U-boats of this type differ from the normal German submarine practice in that their forward hydroplanes are above water when in surface trim and turn in to the casing when not in use. The usual German practice has been for U-boats to have their forward hydroplanes fixed in the " turned out " position and " drowned "—that is, set low down on the hull below the torpedo tubes, so that they are always below water. In the type " 21 " U-boat the designers have adopted exactly the opposite principle.

The whole of the conning tower and bridge structure is very carefully streamlined. The bridge itself is covered with light armour plating as a protection against machine gun attack from the air, and this, of course, adds to its streamlines. In this armoured top to the bridge there are two spaces, one on each side of the bridge, for the heads and shoulders of the look-outs. Just before these there is a central " hole in the roof," through which projects a simple type of night torpedo sight. This sight is fitted with a pair of large night binoculars, which are immensely heavy. The reason is that they are water and pressure-tight, and are also tested to a depth of 900ft. Thus they can safely be left in place on the night sight without fear of becoming flooded and useless when the U-boat has to " crash dive."

The Germans seem to go to great lengths in

PORTS AND ARCHITECTURE OF BRAZIL

(*For description see opposite page*)



THE WATER FRONT OF RIO DE JANEIRO
THE PORT OF SANTOS

AVENIDA RIO BANCO, RIO DE JANEIRO
THE YPIRANGA MEMORIAL, SAO PAULO

their streamlining, and when the "schnorkel" came into use and led to the U-boats remaining under water throughout their operational trips, so that quick diving and quick surfacing lost their importance, they seized the opportunity of increasing the streamlining of the superstructure of their U-boats by doing away with the flooding and draining ports in the free-flooding structure. In some U-boats one can see where patches have been welded in to eradicate these ports.

(To be continued)

An Engineer Looks at Brazil

By ROLT HAMMOND, A.C.G.I., Assoc. M. Inst. C.E.

No. I

RIO DE JANEIRO is one of the most beautiful cities in the world. Art and imagination have been perfectly mingled to bestow upon this city of nearly two million souls, the second largest in Latin America and capital of the United States of Brazil, its remarkable character. Its amazingly rapid growth during the last half century is an index of that spirit of enterprise and restless energy which animates modern Brazil, a country abounding in rich natural resources.

In Rio itself the Government Buildings, the Municipal Theatre, the School of Art, and the Supreme Court of Law show by their varied styles of architecture the many different influences which have contributed to the making of this great country; a note of extreme modernity is struck by the building of the Press Association, in which the influence of Le Corbusier is reflected. Rio's show street is the Avenida Rio Branco, laid out on the finest principles of modern city planning, surpassed only by a promenade of white marble stretching almost unbroken for a distance of 5 miles. Rio is a symbol of Brazil as a whole, a country of sharp contrasts, exemplified by the fact that the primeval forest reaches to the very back blocks of the city; within a few miles of this ultra-modern metropolis dwell primitive tribes living in little better conditions than those of their remote forefathers.

The United States of Brazil is in reality a sub-continent, comprising nearly half of South America and covering an area sixty-five times that of England and greater than that of the United States. It is the fourth largest nation in the world, its frontiers touching every nation on the continent except Ecuador and Chile.

Brazilian history is full of romance and flamboyant exuberance, but it is a great mistake to imagine that an atmosphere of *opéra bouffe* is typical of the Latin American republics; this is an unfortunate misconception widely held in Great Britain. The country was discovered by Pedro Alvares Cabral, known as the Portuguese Columbus, in 1500, and early colonisation centred on the port of Bahia; in 1552 Thomé de Souza landed at Rio, exclaiming, "Tudo e graca que se dele pode decir"—"Everything here is of a beauty which can hardly be described."

FIG. 2—PALACE OF JUSTICE, PERNAMBUCO

Manoel de Nobrega, a Jesuit, had a profound influence on the early development of Brazil; in 1549 he was Provincial Governor of Bahia, and he displayed remarkable administrative abilities, both in this task and in the founding of São Paulo, the Manchester of modern Brazil. In order to develop the country, the Portuguese imported large numbers of slaves; the only colonists to arrive of their own accord were the "Cristãos novos," or newly baptised Jews, who preferred to risk the uncertainties of Brazil rather than to endure persecution in Europe. They, too, had a far-reaching effect on the future of this land.

Modern Brazil can be said to date from the year 1808; Napoleon invaded Portugal, causing Dom João, its ruler, to flee from his country and to seek sanctuary in Brazil. Thus Brazil became an empire, a striking fact unique in Latin American history; Dom João returned to Lisbon, his mantle falling on Dom Pedro, who thereupon became regent. Then an astonishing event took place: Portuguese rule was overthrown and Dom Pedro created Emperor Pedro I. Thus a rich and powerful Imperial court came into being, overshadowing in magnificence that of the mother country. During the nineteenth century immigration flourished on a huge scale to meet the labour demands of an expanding country; Italians developed São Paulo, Germans flocked to the rolling cattle lands of Rio Grande do Sul. Slavery was abolished in 1888 and a year later this was the main political issue which resulted in the dethronement of Dom Pedro II, who had nevertheless ruled his country in an exemplary manner for nearly half a century.

The constitution of the Republic, the Estados Unidos do Brasil, was laid down in 1891 and was modelled closely on that of the United States. Recent Brazilian history is closely linked with the meteoric rise to power of that forceful personality, Getulio Vargas, who has worked miracles in developing the resources of his country and in bringing about many far-reaching social and political reforms. His dynamic leadership has done much towards extending the industrialisation of Brazil.

In early colonial times, it was perhaps extremely fortunate that the economic structure of Brazil was founded on such pursuits as forestry, farming, and stock raising; it is significant, for example, that the country derives its name from the wood known as "brazil," a dyewood found in the region of Pernambuco. These agricultural activities were well established during the early days of colonial expansion, when land was so cheap that it could almost be had for the asking.

The country was mercifully spared the cruelties and oppressions inflicted by the *conquistadores* and treasure seekers on Me xico

FIG. 1—RIO DE JANEIRO AND ITS BAY