

Secret

Register No. 256

GERMAN NAVY (Submarines)

MARCH, 1917

Reprint of British Admiralty Publication

NAVY DEPARTMENT
OFFICE OF NAVAL INTELLIGENCE

July, 1917



BLOCK SKETCHES OF GERMAN SUBMARINES.

SCALE 2 INCHES = 86 FT.

C.B. 1182.
Part III.
July, 1917.
At beginning of Section 5.



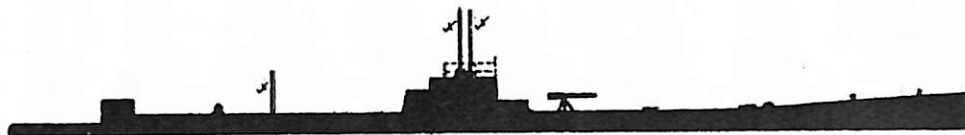
"U. 9."



"U. 16."



"U. 17."



"U. 19-22."



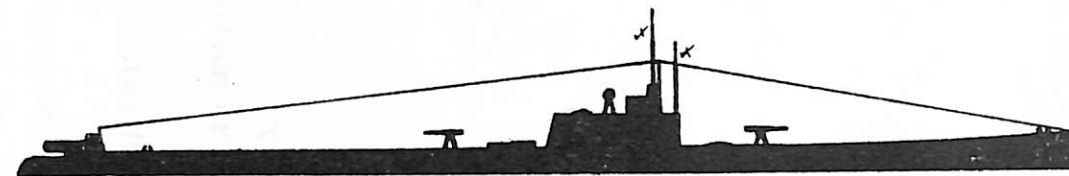
"U. 24-25."



"U. 28-30."

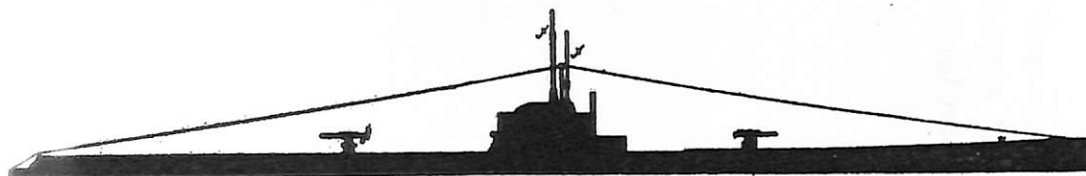


"U. 32-39."



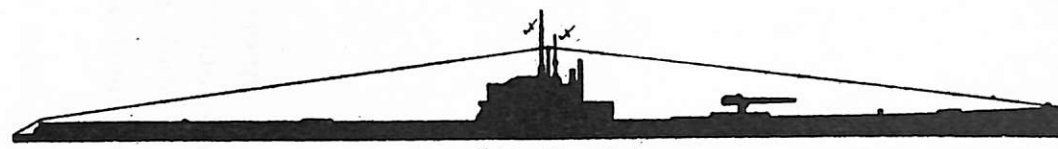
"U. 43-50."

Note.—In several of these boats, the 2 - 22 prs. have been replaced by 1 - 4'1" gun. mounted forward.



"U. 52-62."

With 2-22 pr. guns.



"U. 52-62."

With 1-4'1 in. gun.



"U.B. 1-17."



"U.B. 18-47."



"U.C. 1-15."



* "U.C. 16-79."

** Note.—Some of these submarines have a straight or even overhanging stem, and the conning towers differ slightly.*

x Disappearing

SECRET.

NAVY DEPARTMENT,
OFFICE OF NAVAL INTELLIGENCE,
Washington, June 26, 1917.

This pamphlet is a reprint of a confidential British publication which this office is authorized to republish.

It is very important that this information should be kept secret.

No person not a commissioned officer of the Navy should be allowed to examine this pamphlet.

ROGER WELLES,
Captain, United States Navy,
Director of Naval Intelligence.

CONFIDENTIAL.

Attention is called to the Penalties attaching to any infraction of the Official Secrets Act.

Part III.
Section 5.

March
1917.

C.B. 1182.

GERMAN NAVY.

PART III.

SECTION 5.

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DETAILS OF

Part III.
Section 5.
Submarines.

Official No.	Type. Hull.	Where Built.	Date of first Commissioning.	Complement. (a) Officers. (b) Men.	Dimensions.		Displacement. Surfaced. Submerged.	Armament.	Motive Power.	
					(a) Length.	(b) Breadth. (c) Draught.			Surface.	Submerged.
U. 130....	Ocean-going. Double hull.				Ft.	Ins.	Tons			
U. 129....										
U. 128....										
U. 127....										
U. 126....										
U. 125....										
U. 124....										
U. 123....										
U. 122....	Ocean-going. Double hull.				Ft.	Ins.	Tons			
U. 121....										
U. 120....	Ocean-going. Double hull.				Ft.	Ins.	Tons			
U. 119....										
U. 118....										
U. 117....										
U. 116....										
U. 115....										
U. 114....										
U. 113....										
U. 112....	Ocean-going. Double hull.				Ft.	Ins.	Tons			
U. 111....										
U. 110....	Ocean-going. Double hull.				Ft.	Ins.	Tons			
U. 109....										
U. 108....										
U. 107....										
U. 106....										
U. 105....										
U. 104....										
U. 103....										
U. 102....	Ocean-going. Double hull.				Ft.	Ins.	Tons			
U. 101....										

SUBMARINES.

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H. P. Surface. Submerged.	No. of Propellers.	Speed.		Radius of Action at Economical Speed.	Fuel and Fuel Stowage.	Batteries. No. of Cells. Type.	Periscopes.	Remarks.
		Surface.	Submerged.					
				Knots.	Miles.			
								May be completed in first half of 1917.
								May be completed in first half of 1917.
								May be completed in first half of 1917.

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Official No.	Type. Hull.	Where Built.	Date of first Commissioning.	Complement. (a) Officers. (b) Men.	Dimensions.		Displacement. Sur- face. Sub- merged.	Armament.	Motive Power.	
					(a) Length.	(b) Breadth.			(c) Draught.	Surface.	Submerged.
U. 100.....	Ocean-going. Double hull.		1916-17		Ft. Ins.	Tons.		1—4. 1"; 1—m.; 4 bow S.T.; 2 stern S.T.	Diesel engines, 4-cycle, 6-cylinders. A.E.G. motors.	
U. 99.....										
U. 98.....										
U. 97.....										
U. 96.....										
U. 95.....										
U. 94.....										
U. 93.....	Ocean-going. Double hull.	Germania Yard, Kiel.	1916-17		Ft. Ins.	Tons.	1—4. 1"; 1—m.; 2 bow S.T.; 2 stern S.T.; 12 torpedoes.	Diesel engines, (?) 4-cycle, 6-cylinders. A.E.G. motors.		
U. 86.....										
U. 85.....										
U. 84.....										
U. 82.....										
U. 81.....										
U. 80.....										
U. 79.....	Ocean-going minelayers. Double hull.	Vulcan Works, Hamburg.	1916		Ft. Ins.	Tons.	1—4. 1" or 2—22-pr.; 1—m.; 2 bow T. (19. 7"); 1 stern T. (19. 7"); 34 mines.	Diesel engines, 4-cycle, 6-cylinders. A.E.G. motors.		
U. 78.....										
U. 75.....										
U. 73.....										
U. 72.....										
U. 71.....										
U. 70.....	Ocean-going. Double hull.	Germania Yard, Kiel.	1915	(a) 7 (b) 30	Ft. Ins.	Tons.	1—4. 1" or 2—22-pr.; 1—m.; 4 bow S.T. (19. 7"); 1 stern S.T. (19. 7"); 12 torpedoes.	Diesel engines, 2-cycle, 6-cylinders. A.E.G. motors.		
U. 69.....										
U. 67.....										
U. 66.....										

* Approximate only.

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H. P. Surface. Submerged.	No. of Propellers.	Speed.		Radius of Action at Economical Speed.		Fuel and Fuel Stowage.†	Batteries. No. of Cells. Type.	Periscopes.	Remarks.
		Surface.	Submerged.	Surface.	Submerged.				
			Knots.		Miles.				
	2		18*						
			10*						
	2		18*						Superstructure rounded at sides over tops of tanks. Bow slightly rounded.
			10*						
	2		10			Heavy oil.....			Differ greatly from all other "U" boats. See p. 29.
			7						
2,600	2		17.5		10,000	Heavy oil..... 155* tons.	220 cells.	2 passing through conning tower, 1 passing through fore part of fair-water.	Originally building for Austria-Hungary. A very successful class. Tops of tanks exposed. Straight stem. For general details, see Plate 80.
			9						

†Including stowage in ballast tanks generally appropriated for fuel on long cruises.

Part III.
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Sub-
marines.

Official No.	Type. Hull.	Where Built.	Date of first Commissioning.	Comple-ment. (a) Officers. (b) Men.	Dimen-sions.		Dis-place-ment. Sur-face. Sub-merged.	Armament.	Motive Power.	
					(a) Length.	(b) Breadth.			Surface.	Submerged.
					Ft.	Ins.	Tons.		Surface.	Submerged.
U. 65.....	Ocean-going. Double hull.	Germania Yard, Kiel.	1916	(a) 7	(a) 235 0*	800	1—4. 1'' or 2—22-pr.; 1—m.; 4 bow S.T. (19. 7''); 2 stern S.T. (19. 7'').	Diesel engines, special type, originally intended for Russian Navy; 2-cycle, 6 cylinders.	Surface.	Submerged.
U. 64.....				(b) 30	(b) 21 0*	1,150*				
U. 63.....				(c) 12 0*	1,150*					
U. 62.....	Ocean-going. Double hull.	Weser Yard, Bremen.	1916	(a) 7	(a) 230 0*	750	1—4. 1'' or 2—22-pr.; 1—m.; 2 bow S.T. (19. 7''); 2 stern S.T. (19. 7''); 10 torpedoes.	Diesel engines, 4-cycle, 6 cylinders.	Surface.	Submerged.
U. 61.....				(b) 30	(b) 20 0*	1,000*				
U. 60.....				(c) 12 0*	1,000*					
U. 59.....										
U. 58.....										
U. 57.....										
U. 55.....										
U. 54.....										
U. 53.....										
U. 52.....										
U. 50.....	Ocean-going. Double hull.	Imperial Dockyard, Danzig.	1915-16	(a) 7	(a) 230 0*	750	1—4. 1'' or 2—22-pr.; 1—m.; 4 bow S.T. (19. 7''); 2 stern S.T. (19. 7''); 10 torpedoes.	Diesel engines, 4-cycle, 6 cylinders.	Surface.	Submerged.
U. 49.....				(b) 30	(b) 20 0*	1,050*				
U. 48.....				(c) 12 0*	1,050*					
U. 47.....										
U. 46.....										
U. 45.....										
U. 44.....										
U. 43.....										
U. 39.....	Ocean-going. Double hull.	Germania Yard, Kiel.	1914	(a) 7	(a) 230 0*	750	1—4. 1'' or 2—22-pr.; 1—m.; 2 bow S.T. (19. 7''); 2 stern S.T. (19. 7''); 8 torpedoes.	Diesel engines, 2-cycle, 6 cylinders.	Surface.	Submerged.
U. 38.....				(b) 28	(b) 20 0*	1,000*				
U. 35.....				(c) 12 0*	1,000*					
U. 33.....										
U. 32.....	Ocean-going. Double hull.	Germania Yard, Kiel.	1914	(a) 7	(a) 230 0*	750	1—4. 1'' or 2—22-pr.; 1—m.; 2 bow S.T. (19. 7''); 2 stern S.T. (19. 7''); 8 torpedoes.	Diesel engines, 2-cycle, 6 cylinders.	Surface.	Submerged.
U. 30.....				(b) 28	(b) 22 0*	1,000*				
U. 28.....		Imperial Dockyard, Danzig.	26. 6. 14	(c) 12 6*	1,000*					

* Approximate only.

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marines.

H.P. Surface.	No. of Pro-pellers.	Speed.		Radius of Action at Economical Speed.	Fuel and Fuel Stowage.†	Batteries. No. of Cells. Type.	Periscopes.	Remarks.
		Surface.	Submerged.					
Sub-merged.				Surface. Submerged.				
				Knots.	Miles.			
2,600*	2	17.5	9.0	9,700	Heavy oil. 150* tons.			Superstructure rounded at sides over tops of tanks. Bow slightly rounded.
—	—	—	—	—	—			
2,200*	2	17.0	9.0	8,500	Heavy oil. 120* tons.		3, passing through conning tower.	Tops of tanks exposed. Straight stem. For general appearance and conning tower, see Plate 81.
—	—	—	—	—	—			
2,000	2	15.5	8.0	5,500*	Heavy oil. 84* tons.	220 cells	2, passing through conning tower.	Superstructure rounded at sides over tops of tanks. Bow slightly rounded.
—	—	—	—	100*	—			
2,200*	2	16.5	9.0	5,000*	Heavy oil. 75* tons.	220 cells	2, passing through fore part of conning tower.	For general appearance and conning tower, see Plates 82 and 83.
—	—	—	—	100*	—			
2,000*	2	16*	8*	4,700*	Heavy oil. 70* tons.	220 cells	2, passing through fore part of conning tower.	For general appearance, see Plate 84.
800*	—	—	—	100*	—			

† Including stowage in ballast tanks generally appropriated for fuel on long cruises.

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Sub-
marines.

Official No.	Type. Hull.	Where Built.	Date of first Commissioning.	Comple-ment. (a) Officers. (b) Men.	Dimen-sions. (a) Length. (b) Breadth. (c) Draught.		Dis-place-ment. Sur-face. Sub-merged.	Armament.	Motive Power.	
					Ft.	Ins.			Tons.	Surface.	Submerged.
U. 25.....	Ocean-going. Double hull.	Germania Yard, Kiel.	9. 5. 14	(a) 6 (b) 24	(a) 220	0*	700*	1—22-pr.; 1—m.; 2 bow S. T. (19.7''); 2 stern S. T. (19.7''); 8 torpedoes.	Diesel engines 4-cycle, 6 cylinders.	A. E. G. motors.
U. 24.....			6. 12. 13		(b) 20	0*				
U. 22.....			21. 11. 13		(c) 12	0*					950*
U. 21.....	Ocean-going. Double hull.	" "	22. 10. 13	(a) 6 (b) 24	(a) 220 (b) 20 (c) 12	0* 0* 0*	700*	1—22-pr.; 1—m.; 2 bow S. T. (19.7''); 2 stern S. T. (19.7''); 8 torpedoes.	Diesel engines 4-cycle, 6 cylinders.	A. E. G. motors.
U. 19.....	Ocean-going. Double hull.	" "	6. 7. 13	(a) 6 (b) 22	(a) 210 (b) 19 (c) 12	0* 0* 0*	600*	1—22-pr.; 1—m.; 2 bow S. T. (17.7''); 2 stern S. T. (17.7''); 8 torpedoes.	Diesel engines 4-cycle, 6 cylinders.	A. E. G. motors.
U. 17.....	Ocean-going. Double hull.	" "	3. 11. 12	(a) 6 (b) 22	(a) 180	0*	500*	1—22-pr.; 1—m.; 2 bow S. T. (17.7''); 2 stern S. T. (17.7''); 8 torpedoes.	Körting paraffin engines 2-cycle, 6 cylinders.	A. E. G. motors.
U. 16.....			28. 12. 11		(b) 18	6*					(c) 11	6*	640*
U. 9.....	Sea-going. Double hull.	Imperial Dockyard, Danzig.	18. 4. 10	(a) 6 (b) 22	(a) 175 (b) 18 (c) 11	0* 6* 6*	400*	1—4-pr.; 1—m.; 2 bow S. T. (17.7''); 2 stern S. T. (17.7''); 6 torpedoes.	Körting paraffin engines, 2-cycle.	A. E. G. motors.
U. 4.....	Instructional. Double hull.	" "	1. 7. 09	(a) 5 (b) 20	(a) 166	0*	350*	1—4-pr.; 2 bow S. T. (17.7''); 2 stern S. T. (17.7'').	Körting paraffin engines, 2-cycle.	A. E. G. motors.
U. 3.....			29. 5. 09		(b) 18	9*					(c) 10	6*	500*
U. 2.....	Instructional. Double hull.	" "	18. 7. 08	(a) 141 (b) 12 (c) 9	9* 3* 7*	233* 295*	2 bow S. T. (17.7'').	Körting paraffin engines.	A. E. G. motors.	
U. 1.....	Instructional. Double hull.	Germania Yard, Kiel.	14. 12. 06	(a) 138 (b) 11 (c) 10	9 10 2	197 236	1 bow S. T. (17.7''); 3 torpedoes.	Körting paraffin engines, 2-cycle, 6 cylinders.	A. E. G. motors.	
U. A.....	Instructional. Double hull.	"	— 8. 14	(a) 3 (b) 14	(a) 150 (b) 16 (c)	0 6 6	246 332	1—4-pr. (?); 2 bow S. T. (17.7''); 1 deck T. (17.7''); 4 torpedoes.	A. E. G. motors. Diesel engines.	A. E. G. motors.

* Approximate only.

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Sub-
marines.

H. P. Surface. Sub-merged.	No. of Pro-pellers.	Speed.		Radius of Action at Economical Speed.	Fuel and Fuel Stowage.†	Batteries. No. of Cells. Type.	Periscopes.	Remarks.
		Surface.	Submerged.					
1,900*	2	Knots.	Miles.	5,000*	Heavy oil, 70* tons.	.....	2, passing through fore part of conning tower.	For general appearance, see Plate 84.
800*		16*	8*					
1,900*	2	16*	5,000*	5,000*	Heavy oil, 70* tons.	2, passing through fore part of conning tower.	Conning tower and exposed portion of hull protected by nickel steel armour, 1.2" and 1" thick. Otherwise resembles U. 22 to 25 (see Plate 84). This was the first submarine to be sent to the Irish Sea and again the first to be sent to the Mediter-ranean. After her arrival in the Mediterranean she was officially called "U. 51."
800*		8*	100*					
1,800*	2	15*	4,250*	4,250*	Heavy oil, 55* tons.	.....	2, passing through conning tower.	Generally resembles U. 16-18, see Plate 84, but conspicuous exhaust funnel has been replaced by a smaller funnel, slanting aft.
800*		8*	—					
1,200*	2	14*	2,750	2,750	Paraffin, 45* tons.	.....	2, passing through conning tower.	For general appearance, see Plate 84, but conspicuous exhaust funnel has been replaced by a smaller funnel, slanting aft.
800*		8*	—					
1,000*	2	13*	.....	.....	Paraffin	.....	2, passing through conning tower.	For general appearance, see Plate 85. Conspicuous ventilator and funnel have been removed. A smaller funnel is fitted, slanting aft.
600*		8*						
880*	2	12.5	.....	.....	Paraffin	.....	2, passing through conning tower.	For general appearance, see Plate 85.
600*		8						
600*	2	12	.....	.....	Paraffin	.....	2, passing through conning tower.	Pressure hull is about 147½ ft. long, with a pressure proof bulkhead separating fore torpedo room (about 24½ ft. long) from rest of hull. Watertight door in bulkhead.
320*		8						
450	2	10.9	.....	.....	Paraffin, 20 tons.	.....	2, passing through conning tower.	The forerunner of all U. boats. Built from designs by d'Equi-villey-Montjustin.
250		8.7						
.....	2	14	.....	.....	Heavy oil.	.....	.....	Built for Norway, but taken over by German Navy, prior to delivery, on 7.8.14.
.....		9						

† Including stowage in ballast tanks generally appropriated for fuel on long cruises.

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Section 5.
Submarines.

Official No.	Type. Hull.	Where Built.	Date of first Commissioning.	Comple-ment. (a) Officers. (b) Men.	Dimen-sions.			Dis- placement. Sur- face. Sub- merged.	Arma- ment.	Motive Power.	
					(a) Length.	(b) Breadth.	(c) Draught.			Surface.	Submerged.
					Ft.	Ins.	Tons.				
U. B. 65...											
U. B. 64...											
U. B. 63...											
U. B. 62...											
U. B. 61...											
U. B. 60...											
U. B. 59...											
U. B. 58...											
U. B. 57...											
U. B. 56...	Coastal										
U. B. 55...											
U. B. 54...											
U. B. 53...											
U. B. 52...											
U. B. 51...											
U. B. 50...											
U. B. 49...											
U. B. 48...											
U. B. 47...											
U. B. 45...											
U. B. 44...											
U. B. 43...											
U. B. 42...											
U. B. 41...	Coastal.	Weser Yard, Bremen.									
U. B. 40...	Single hull with saddle tanks.							1—22-pr.; 1—m.; 2 bow S.T. (19.7''), one above the other; 4 torpedoes.	Two 6-cylinder 4-cycle Diesel engines.	Heavy oil, 29 tons.†	
U. B. 39...											
U. B. 38...											
U. B. 37...											
U. B. 36...											
U. B. 35...	Coastal.	Blohm & Voss Works, Hamburg.	1916	(a) 3 (b) 18	(a) 119 0 (b) 14 8 (c) 11 6	250	290	Two Siemens-Schuckert motors, each with two armatures in tandem.			
U. B. 34...											
U. B. 33...											
U. B. 32...	Single hull with saddle tanks.										
U. B. 31...											
U. B. 30...											

(Interned in Holland 26.2.17.)

SUBMARINES.

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Section 5.
Submarines.

H. P. Surface. Submerged.	No. of Pro-pellers.	Speed.	Radius of Action at Economical Speed.	Fuel and Fuel Stowage.†	Batteries. No. of Cells. Type.	Periscopes.	Remarks.
		Surface. Submerged.	Surface. Submerged.				
		Knots.	Miles.				
285	2	8.5	4,500	Heavy oil, 29 tons.†	112 Tudor lead cells.	2; one passing through conning tower, one through fairwater just abaft it.	See p. 31 and Plates 86, 88, and 89.
250		6.0	70				

† Including stowage in ballast tanks, which can be appropriated for fuel on long cruises.

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Official No.	Type. Hull.	Where Built.	Date of first Commissioning.	Comple-ment. (a) Officers. (b) Men.	Dimen-sions. (a) Length. (b) Breadth. (c) Draught.		Dis-place-ment. Sur-face. Sub-merged.	Armament.	Motive Power.									
					Ft.	Ins.			Tons.	Surface.	Submerged.							
U. B. 28... U. B. 27... U. B. 25... U. B. 24...	Coastal. Single hull with saddle tanks.	Weser Yard, Bremen.	1915-16	(a) 3 (b) 18	(a) 119 0	250	1-22-pr.; 1-m.; 2 bow S.T. (19.7''), one above the other; 4 torpedoes.	Two 6-cylinder 4-cycle Diesel engines.	Two 6-cylinder 4-cycle Diesel engines.									
(b) 14 8					290						Two Siemens-Schuckert motors, each with two armatures in tandem.							
(c) 11 6																		
U. B. 23... U. B. 22... U. B. 21... U. B. 20... U. B. 18...					Coastal. Single hull with saddle tanks.						Blohm & Voss Works, Hamburg.							
U. B. 17... U. B. 16... U. B. 15... U. B. 14... U. B. 13... U. B. 12... U. B. 11... U. B. 10... U. B. 9...	Small coastal. Single hull.	Blohm & Voss Works, Hamburg.	1915	(a) 1 (b) 11		(a) 90 0	125	1-1-pr. or 1 m.; 2 bow S.T. (19.7'') fitted abreast; 2 torpedoes.	One Diesel engine.									
(b) 10 0						140												
(c) 9 9																		
U. B. 8... U. B. 7... U. B. 6... U. B. 5... U. B. 3... U. B. 2... U. B. 1...						Small coastal. Single hull.	Weser Yard, Bremen.											

Part III.
Section 5.
Sub-marines.

H.P. Surface. Sub-merged.	No. of Pro-pellers.	Speed. Surface. Submerged.		Radius of Action at Economical Speed. Surface. Submerged.		Fuel and Fuel Stowage.†	Batteries. No. of Cells. Type.	Periscopes.	Remarks.
		Knots.	Miles.	Surface.	Submerged.				
285	2	8.5	4,500	Heavy oil. 29 tons.†	112 Tudor lead cells.	2; one passing through conning tower, one through fairwater just abaft it.	See p. 31 and Plates 86, 88, and 89.		
250		6	70						
60	1	8.4‡	2,000	Heavy oil. 2.4 tons.	112 Tudor lead cells.	1, passing through conning tower.	See p. 35 and Plate 86.		
120		5	45						

† Including stowage in ballast tanks, which can be appropriated for fuel on long cruises.
‡ With motors for a short period, but only 6.5 knots with Diesel engine.

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Section 5.
Sub-marines.

Official No.	Type. Hull.	Where Built.	Date of first Commissioning.	Complement. (a) Officers. (b) Men.	Dimensions. (a) Length. (b) Breadth. (c) Draught.			Displacement. Sur-face. Sub-merged.	Armament.	Motive Power.					
					Ft. Ins.	Tons.	Surface.			Submerged.					
U. C. 99....															
U. C. 98....															
U. C. 97....															
U. C. 96....															
U. C. 95....															
U. C. 94....															
U. C. 93....															
U. C. 92....															
U. C. 91....															
U. C. 90....															
U. C. 89....	Minelaying. Double hull.	Vulcan Works, Hamburg.	1916-17	(a) 4 (b) 19	(a) 162 3 (b) 17 1 (c) 12 0	395 475	1—22-pr.; 1—m.; 2 bow T. (19.7"); 1 stern S.T. (19.7"); 4 torpedoes; 18 mines.	Two 6-cylinder 4-cycle Diesel engines. Electric motors.	600* 230*	2	12.0* 7.0*	6,000‡ —	Heavy oil, 40 tons (normal stowage).	124 cells	2, passing through conning tower.
U. C. 88....															
U. C. 87....															
U. C. 86....															
U. C. 85....															
U. C. 84....															
U. C. 83....															
U. C. 82....															
U. C. 81....															
U. C. 80....															
U. C. 79....	Minelaying Double hull	Germania Yard, Kiel.	1916-17	(a) 4 (b) 19	(a) 165 2* (b) 17 5* (c) 12 2*	430* 513*	1—22 pr.; 1—m.; 2 bow T. (19.7"); 1 stern S.T. (19.7"); 4 torpedoes; 18 mines.	Two 6-cylinder 4-cycle Diesel engines. Electric motors.	600* 230*	2	12.5* 7.0*	6,000‡ —	Heavy oil, 40 tons* (normal stowage).	124 cells.	2, passing through conning tower.
U. C. 78....															
U. C. 77....															
U. C. 76....															
U. C. 75....															
U. C. 74....															
U. C. 73....															
U. C. 72....															
U. C. 71....															
U. C. 70....															
U. C. 69....															
U. C. 68....															
U. C. 67....															
U. C. 66....															
U. C. 65....															

* Approximate only.

Part III.
Section 5.
Sub-marines.

H.P. Surface. Submerged.	No. of Propellers.	Speed. Surface.		Radius of Action at Economical Speed. Surface. Submerged.	Fuel and Fuel Stowage.	Batteries. No. of Cells. Type.	Periscopes.	Remarks.
		Surface.	Submerged.					
			Knots.	Miles.				
								Believed to be under construction in March 1917. Probably represent an improvement on U.C. 16-79 (see below).
								See p. 37 and Plate 90. In endurance and radius of action closely approach the regular ocean-going type of submarine ("U" boats).

‡ Calculated on normal fuel stowage; can be considerably increased by using ballast tanks for extra fuel.

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Part III.
Section 5.
Submarines.

Official No.	Type. Hull.	Where Built.	Date of first Commissioning.	Comple-ment. (a) Officers. (b) Men.	Dimen-sions. (a) Length. (b) Breadth. (c) Draught.		Dis-place-ment. Sur-face. Sub-merged.	Armament.	Motive Power.																					
					Ft.	Ins.			Tons.	Surface.	Submerged.																			
U. C. 64... U. C. 63... U. C. 62... U. C. 61...	Minelaying. Double hull.	Weser Yard, Bremen.	1916-17	(a) 4 (b) 19	(a) 165 (b) 17 5 (c) 12 2	2* 5* 2*	430* 513*	1—22 pr.; 1—m.; 2 bow T. (19.7''); 1 stern S.T. (19.7''); 4 torpedoes; 18 mines.	Two 6-cylinder 4-cycle Diesel engines.	Electric motors.																				
U. C. 60... U. C. 59... U. C. 58... U. C. 57... U. C. 56... U. C. 55...									Minelaying. Double hull.	Imperial Yard, Danzig.	1916-17	(a) 4 (b) 19	(a) 165 (b) 17 5 (c) 12 2	2* 5* 2*	430* 513*	Two 6-cylinder 4-cycle Diesel engines.	Electric motors.													
U. C. 54... U. C. 53... U. C. 52... U. C. 51... U. C. 50... U. C. 49... U. C. 48... U. C. 47... U. C. 46...																Minelaying. Double hull.	Weser Yard, Bremen.	1916-17	(a) 4 (b) 19	(a) 165 (b) 17 5 (c) 12 2	2* 5* 2*	430* 513*	Two 6-cylinder 4-cycle Diesel engines.	Electric motors.						
U. C. 45... U. C. 44... U. C. 43... U. C. 42... U. C. 41... U. C. 40...																							Minelaying. Double hull.	Vulcan Works, Hamburg.	1916	(a) 4 (b) 19	(a) 162 (b) 17 1 (c) 12 0	3 1 0	395 475	Two 6-cylinder 4-cycle Diesel engines.	Electric motors.
U. C. 38... U. C. 37... U. C. 36... U. C. 35... U. C. 34...	Minelaying. Double hull.	Blohm & Voss Works, Hamburg.	1916	(a) 4 (b) 19	(a) 165 (b) 17 5 (c) 12 2	2 5 2	430 513	Two 6-cylinder 4-cycle Diesel engines.																						Electric motors.

* Approximate only.

Part III.
Section 5.
Submarines.

H. P. Surface. Submerged.	No. of Propellers.	Speed. Surface. Submerged.		Radius of Action at Economical Speed. Surface. Submerged.		Fuel and Fuel Stowage.	Batteries. No. of Cells. Type.	Periscopes.	Remarks.
		Miles.	Knots.	Miles.	Knots.				
600* 230*	2	12.0* 7.0*	6,000¶ —	Heavy oil, 40 tons (normal stowage).	124 cells	2, passing through conning tower.			
600* 230*	2	12.0* 7.0*	6,000¶ —	Heavy oil, 40 tons (normal stowage).	124 cells	2, passing through conning tower.			
600* 230*	2	12.0* 7.0*	6,000¶ —	Heavy oil, 40 tons (normal stowage).	124 cells	2, passing through conning tower.			

¶ Calculated on normal fuel stowage; can be considerably increased by using ballast tanks for extra fuel.

See p. 37 and Plate 90. In endurance and radius of action closely approach the regular ocean-going type of submarine ("U." boats).

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Part III.
Section 5.
Sub-
marines.

Official No.	Type. Hull.	Where Built.	Date of first Commissioning.	Comple-ment. (a) Officers. (b) Men.	Dimen-sions.			Dis-placement. Sur-face. Sub-merged.	Arma-ment.	Motive Power.															
					(a) Length.	(b) Breadth.	(c) Draught.			Station.	Submerged.														
U. C. 33... U. C. 31... U. C. 30... U. C. 29... U. C. 28... U. C. 27... U. C. 26... U. C. 25...	Minelaying Double hull	Vulcan Works, Hamburg.	1916	(a) 4 (b) 19	(a) 162 3	(b) 17 1	(c) 12 0	395	1—22-pr.; 1—m.; 2 bow T. (19.7''); 1 stern S.T. (19.7''); 4 torpedoes; 18 mines.	Two 6-cylinder 4-cycle Diesel engines.															
U. C. 24... U. C. 23... U. C. 22... U. C. 21... U. C. 20... U. C. 18... U. C. 17... U. C. 16...					Minelaying Double hull	Blohm & Voss Works, Hamburg.	1916	(a) 4 (b) 19		(a) 165 2*	(b) 17 5*	(c) 12 2*	430*	1—22-pr.; 1—m.; 2 bow T. (19.7''); 1 stern S.T. (19.7''); 4 torpedoes; 18 mines.	Two 6-cylinder 4-cycle Diesel engines.										
U. C. 15... U. C. 14... U. C. 13... U. C. 11... U. C. 10... U. C. 7... U. C. 6... U. C. 4... U. C. 3... U. C. 1...										Small Mine-laying. Single hull.	Weser Yard, Bremen.	1915	(a) 2 (b) 13		(a) 110 3	(b) 10 4	(c) 9 7	179	1—4 pr. or 1 m.; 12 mines.	One 4 cylinder 4-cycle Diesel engine.					
																		202				Siemens-Schuck-ert motor; 2 armatures in tandem.			
																		(a) 111 6		(b) 10 4	(c) 9 1	177	1—4 pr. or 1 m.; 12 mines.	One 6-cylinder 4-cycle Diesel engine.	
																						194		Electric motor; 2 armatures fitted in tan-dem.	

* Approximate only.

Part III.
Section 5.
Sub-
marines.

H. P. Surface. Sub-merged.	No. of Pro-pellers.	Speed.		Radius of Action at Economical Speed.		Fuel and Fuel Stowage.	Batteries. No. of Cells. Type.	Periscopes.	Remarks.
		Surface.	Submerged.	Surface.	Submerged.				
500	2	11.5		Knots.		Heavy oil, 40 tons (normal stowage).	124 cells	2, passing through conning tower.	See p. 37 and Plate 90. Represent a very great improvement on the series U.C. 1-15, and in endurance and radius of action closely approach the regular ocean-going type of submarine ("U." boats).
230		7.0		—					
600*	2	12.5*		Knots.		Heavy oil, 40 tons* (normal stowage).	124 cells	2, passing through conning tower.	
230*		7.0*		—					
80	1	7.5‡		Knots.		Heavy oil, 2.8 tons.	112 Tudor lead cells.	One, passing through conning tower.	
155		5		45					
80	1	7.5‡		Knots.		Heavy oil, 2.3 tons.	220 Tudor lead cells.	One, passing through conning tower.	
155		5		45					

‡With motors, for a short period; but only about 5.7 knots with Diesel engine.

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GENERAL NOTES ON GERMAN SUBMARINES.

I. OCEAN-GOING TYPE ("U" BOATS).

(For general arrangements, see Plates 80 and 87.)

General Remarks.

These vessels are all built with two hulls—a partial outer hull, which is given a shape somewhat like that of a torpedo boat, and an inner, cylindrical pressure hull. Damage to the outer hull alone will not appreciably impair the diving qualities of the submarine, and certainly will not disable her. Should the fuel tanks, which are situated between the inner and outer hull, be penetrated, oil will, of course, appear on the surface. In addition, an arrangement is fitted for ejecting oil in case of accident to mark the position of the submarine. German submarines are instructed to use this arrangement if it appears advisable, in order to mislead and delay an enemy. Oil seen on the surface must, therefore, never be accepted as evidence of a submarine having been sunk, or even damaged.

Cruising Endurance.

Until recently the usual duration of a long cruise was about four weeks, but the tendency now (March 1917) is to reduce the length of cruises, probably on account of more rapid expenditure of torpedoes, which is due to the increased arming of merchant vessels.

Endurance Submerged.

Cases are reported of German submarines spending 28 and 36 hours submerged. It is stated that the crew experienced no serious discomfort after 28 hours.

Colour.

A light French grey, similar to that of larger German vessels, is nearly always adopted. As variations, and by way of disguise, black and white chequers have been used, and occasionally waves are painted on the grey.

The deck is often painted dark grey or black, and the conning tower dark grey.

The periscope is sometimes painted green or in wavy lines of white and grey.

A bow wave is occasionally painted on, to give a false impression of very high speed.

Outer Hull.

The form of the outer hull is chosen solely with regard to sea-going qualities and speed on surface. The space between the inner and outer hulls is occupied by water ballast and oil fuel, in tanks of various size. When the boat is submerged, valves at the bottom of these tanks are opened and thus equilibrium is maintained between the pressure inside and outside the tanks. This enables the outer hull to be constructed of comparatively light plating. On the other hand, the outer hull supplies a great factor of safety against collision or gunfire, particularly in view of the cushion of water or oil between the two hulls.

The outer hull must be regarded essentially as a receptacle for water ballast and oil fuel. If it is holed this will merely entail, at most, a loss of oil fuel, unless the pressure hull also is penetrated.

A strong plate keel is fitted, usually filled with lead pigs. Parts of the keel are detachable, forming safety weights (about 12 tons in modern submarines).

Three projections, like portions of a bilge keel, about five feet in length, are fitted on either side of the boat, one forward, one amidships, and one aft. These take part of the weight when lying on the bottom.

Pressure Hull.

Is of circular section, cylindrical in form amidships, tapering towards the extremities, and with blunt ends. It contains all the machinery and accommodation for crew. In modern submarines it is tested for a depth of 197 feet.

Bulkheads.

The majority of the bulkheads fitted inside the pressure hull are curved both horizontally and vertically, and these are subjected to the same test as the pressure hull. They are known as "pressure bulkheads."

The other bulkheads, which are straight, are watertight or gastight only.

Manholes about four feet in diameter, with the lower edge about 18 inches above the deck, are fitted in all bulkheads.

Ballast Tanks.

Are situated between the inner and outer hulls, on either side and at the ends of the vessel. To extend the radius of action of the submarine, oil may be carried in some of the ballast tanks. The more oil carried, the less will be the normal reserve of buoyancy. But in case of accident the oil can, of course, be blown out in the same way as the water.

Fuel Tanks.

A number of the broadside tanks between the inner and outer hulls are appropriated for oil fuel, and as the fuel is withdrawn for use from the upper part of the tanks, it is automatically replaced by sea water coming under pressure from the main engine cooling system through non-return valves in the bottom of the tanks. Arrangements are made so that only about nine-tenths of the fuel can be withdrawn, so as to prevent water finding its way to the engines.

Compensating Tanks.

Are fitted inside pressure hull below control room for compensating for the weight of stores consumed, sea water being admitted as necessary. The fuel expended being automatically replaced in the fuel tanks by sea water, compensation in this case is only necessary for the difference in specific gravity. The compensating tanks are also used to compensate for variations in the specific gravity of the sea water.

Torpedo Compensating Tanks.

Fitted below torpedo rooms inside pressure hull, and serve to compensate for torpedoes fired, and also to flood the torpedo tubes before opening the sea-caps, so that diving trim shall not be disturbed.

Lubricating Oil Tanks.

Are generally fitted on either side of the engine room, inside the pressure hull.

Trimming Tanks.

Are situated near the extreme ends of the vessel, usually inside the pressure hull. Can be filled with oil instead of water, if desired.

Deck and Superstructure.

In all submarines up to *U. 39* inclusive, in *U. 51-60*, and *U. 66-70*, the upper deck is formed by (1) a superstructure over the pressure hull, about one-third the width of the vessel, merging into the outer hull forward and extending to the rudder post aft; (2) a deck at a lower level on either side, formed by the tops of the tanks.

A noticeable feature in all these submarines is the marked sheer of the bow.

The superstructure is open to the sea through a number of small holes at the level of the deck on either side, and contains fuel and air supply connections, engine muffler boxes, sounding machine, and various safety arrangements, such as telephone and light buoy, lifting shackles and diver's connections. In some submarines a small collapsible boat is carried in fore part of superstructure. In the earlier submarines fitted with 22-pr. guns the guns housed in the superstructure.

In recent submarines the top of the superstructure is 4 to 5 feet above the waterline. Circular manholes are fitted to the tops of the tanks.

In *U. 43-50*, *U. 61-65*, and *U. 81-90*, the superstructure is rounded over to meet the outer hull, and the tops of the tanks are not visible.

In submarines of this type the bow also is slightly rounded.

The space on either side above the tanks is free-flooding, and the middle portion of the superstructure is utilised as described above.

Part III.
Section 5.
Sub-
marines.

Conning Tower.
Is fitted nearly midway between bow and stern. In all the later submarines it is armoured, being constructed, according to report, of about 3-inch nickel steel. It is pressure-proof and can be shut off from the pressure hull by a watertight hatch. The top, which is dome-shaped, is unarmoured. A light bridge is built over it, with surface steering position. The conning tower contains depth gauge, clinometer, engine telegraphs, torpedo firing pistols, gyro receiver, and steering wheel. Communication from conning tower is by voice-pipe.

In recent submarines the bridge is about 8—10 feet above water level. A small chart table, covered with celluloid, is usually fitted on the bridge.

The modern conning tower is roughly oval in section, but somewhat pointed forward, the length, fore and aft, being about 13 feet, and the maximum breadth about 7 feet (*see* U. 66—70, Plate 80). In older submarines the conning tower is circular in section.

The external appearance of the conning tower, surrounded as it is by the fairwater, varies greatly in different classes. Types of conning towers are shown on Plates 81 and 83.

Four or six circular sidelights, provided with hinged dead lights, are usually fitted in the sides of the conning tower. Embrasures are cut in the fairwater to allow for looking nearly ahead or astern through the sidelights. Port and starboard lights are fitted on the conning tower.

Periscopes.

Two periscopes passing through the conning tower are always fitted. In most cases they can both be used either from the conning tower or from the control room below it.

In U. 66—70 class an additional or "emergency" periscope is fitted, passing through the foremost part of the fairwater. It is used from the control room, and is intended to be available in the event of the conning tower being holed and the other two periscopes being put out of action.

In this class the principal periscope (the after one) together with the platform on which the observer stands, ascends and descends inside a shaft passing through the control room.

A small motor is fitted for raising each periscope, and alternative hand-gear is provided. When in the housed position, the periscopes drop into circular wells in the tanks under the control room. The periscopes are revolved by hand. One of them is usually fitted with an all-round prism, to enable the horizon to be searched quickly by revolving the inner periscope tube, the outer tube with the eyepiece remaining stationary; it can also be used in the ordinary way, the outer tube being revolved, and the observer moving round with it.

One at least of the periscopes is bifocal, and also, by the movement of a lever, can be used to search the sky for aircraft, instead of searching the horizon.

One or other of two range-finding devices is fitted to the modern periscopes; these devices can only give very rough results, but are no doubt nevertheless of considerable assistance for torpedo work. The two arrangements are quite different in detail, but in each case a masthead or other known height is used, being compared with a vertical scale, or brought between two cross wires, in the field of view.

The usual field of view is 40°—45°.

The periscope tubes are of nickel steel, the upper tube being usually about 4 feet long, and of from 2.5 to 3 inches external diameter, the lower tube varying from 12 to 25 feet in length, with an external diameter of about 5.9 inches.

When the submarine is proceeding submerged, using her periscope, 2—3 feet of the periscope tube is usually shown above the surface.

The periscopes are believed all to be manufactured by Goerz or Zeiss.

A flashing lamp is usually fitted on one of the periscopes for signalling purposes.

Armament.

Guns.—

All recent large German submarines, except U. 71—80 (*see* p. 29), are fitted with either one 4.1-inch or two 22-pr. guns. The 4.1-inch gun is mounted before the conning tower. Where two 22-pr. guns are carried, one is before, and one abaft, the conning tower. In addition a machine gun is carried and can be mounted on the conning tower.

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Section 5.
Sub-
marines.

Most of the boats which at present (March 1917) carry two 22-pr. guns will be re-armed with one 4.1-inch, as guns become available.

In all modern boats the gun or guns (except machine gun) always remain in position when the submarine submerges. Each gun is mounted on a slightly raised platform which is extended beyond the superstructure on either side and fitted with hand rails. A special form of watertight tampon, like a ginger-beer bottle stopper, is fitted.

Some of the earlier boats carry only one 22-pr. and a machine gun. The 22-pr. is mounted forward.

The 4.1-inch gun carried, which is fitted with telescopic sights, has an effective range of over 13,000 yards. The 22-pr. gun has an effective range of 8,500 yards.

The 4.1-inch is a long gun, semi-automatic. Some of the 22-prs. are of the same type, others are of older pattern.

Percussion firing only is used.

Ammunition Supply.—

As much as 750 rounds of 22-pr. ammunition was carried in U. 66—70 class, and consequently at least 400 rounds of 4.1-inch ammunition will probably be carried in new boats.

In the above-mentioned class, the ammunition is stowed in two magazines, under the fore torpedo room and after torpedo room respectively, and also in four watertight lockers in the superstructure.

The position of the magazines varies in different classes. In some cases a locker for ready supply of ammunition is fitted in fore end of fairwater.

The ammunition is got up by whip (or passed up by hand) through the ordinary hatchways, or, in bad weather, through the conning tower. In some boats the ammunition is transported from the conning tower to the gun by means of a traveller running on the jumping wires.

Torpedo Tubes and Torpedoes.—

The most recent submarines are fitted with either four or two bow and two stern torpedo tubes.

The class U. 71—80 have deck tubes (*see* p. 29).

The class U. 66—70 have four bow tubes, but only one stern tube.

Submarines from U. 3 to U. 39, and the class U. 51—62, are believed all to have two bow tubes and two stern tubes only.

The class U. 43—50 have four bow and two stern tubes.

No broadside tubes, so far as is known, are fitted in any German submarine.

Up to and including U. 20, 17.7-inch torpedoes are carried; from U. 21 onwards, 19.7-inch. It is possible that the most recent submarines carry 20.9-inch torpedoes.

The tubes are fired electrically by air impulse. The firing valves can be worked by hand if necessary.

The number of torpedoes carried in modern boats varies from eight to twelve.

The steel 19.7-inch torpedoes usually carried are of the dry heater type and are fitted with gyroscopes capable of being angled in 15 steps up to 90°. They have a range of 6,800 yards at a speed of about 30 knots. The charge is about 320 lbs., probably of T.N.T.

A proportion of short bronze torpedoes is frequently carried, for use against merchant vessels.

Torpedo net cutters of an explosive type are used.

Mines.—

Are carried only, so far as is known, by submarines of the class U. 71—80 (*see* p. 29), and by the smaller type of submarine known as the "C" type (*see* p. 37).

Bombs.—

Two types of bombs are carried, one being the well-known explosive charge constantly used to sink vessels which have been abandoned by their crews, the other being an incendiary bomb which bursts into flames on being thrown on board a vessel from a boat or from the submarine herself.

The explosive charges are cylindrical in shape, about 5 inches in diameter and 7 inches in length; the fuse, which is about 6 feet long, is supposed to burn for 5 minutes, but in practice burns for 10.

The incendiary bombs are of a similar shape but somewhat larger.

Part III. Wireless Telegraphy.**Section 5.****Sub-marines.**

Usually two masts are fitted to carry the main aerial; they are hinged at the heel and lie aft along the deck when not required. In the more recent boats they can be raised and lowered by wire purchases from inside the hull. The main aerial usually consists of two parts of bare stranded phosphor-bronze wire. Porcelain insulators are fitted. The jumping wires are used as an auxiliary aerial when the submarine is trimmed ready for diving and when the masts cannot be raised. The instruments are either in the control room or just before it. In all recent boats a silent cabinet is fitted.

Wireless communication is practically impossible in heavy weather, as the masts cannot be got up for fear of their going over the side, and the seas breaking over the boat short-circuiting the jumping wires. The wireless set usually fitted is of the Telefunken type and is similar to, if not identical with, the short-range set fitted to larger vessels. The usual transmitting range is 50 to 100 miles, the receiving range larger. The latest submarines, however, have an improved wireless set. A species of valve amplifier, called a "sound-magnifier," is carried. German submarines usually transmit on a wave-length of 1,312 feet and receive on a longer wave-length.

Air Service.

A number of steel bottles containing compressed air at high pressure are carried to enable ballast and other tanks to be blown rapidly. In *U. 66-70* 20 air-bottles are carried, being stowed in pairs in the superstructure. The capacity of each is about 12 cubic feet.

Two air bottles are fitted to the engines for blast and starting purposes.

Ventilation.**(a) When submerged.—**

A great deal of attention is paid to air purification, which is very necessary in view of the large complements carried by German submarines. The system is to absorb the CO₂ by passing the air by means of ventilating fans through a purifier containing fragments of caustic alkali.

In addition, cylinders of oxygen are carried in order to renew the supply of oxygen in the air.

In *U. 66-70* four such cylinders are carried, the capacity of each being about 5½ cubic feet.

Apparatus for testing the condition of the air is carried.

(b) On surface.—

A ventilation tube immediately before the conning tower communicates with the inner hull. The main engines take air from the engine room and thus renewal of the air is ensured.

Safety and Salvage Arrangements.

Are of a most detailed nature, and include light and telephone buoy, lifting shackles and diver's connections on pressure hull, detachable weights, a large supply of air-purifying cartridges, fitted for individual use, safety masks and jackets, &c. Electric torches are provided.

The life-buoys carried are of horse-shoe shape, usually painted red and very conspicuous.

Accommodation.

Owing to the large complements carried, the accommodation in German submarines is extremely cramped. As a rule, there is only one bunk between every two members of the crew (petty officers excepted). The crew work in two watches, six hours on and six hours off.

There are two water-closets, one or both of which can be used when submerged. Steam heaters are fitted and are provided with supply and exhaust connections on upper deck for use in harbour. The engine exhaust gases are also used for heating, and in some cases electric radiators are fitted. An electric cooking stove is fitted.

Part III.**Section 5.****Sub-marines.****Main Engines.**

The earlier submarines, up to *U. 18*, have 2-cycle, 6-cylinder, Körting paraffin engines.

In all submarines from *U. 19* to *U. 20*, 6-cylinder Diesel engines are fitted. Both the 2-cycle and 4-cycle type are in use; the following is believed to be their distribution:—

4-cycle.	2-cycle.
U. 19-23.	U. 24-40.
U. 41-50.	U. 61-70.
U. 51-60.	
U. 71-80.	

Thus of 62 boats, 35 have 4-cycle and 27 have 2-cycle engines.

Air injection is used in all cases. In all boats up to *U. 80*, water-cooling is used for the pistons of the 2-cycle engines, and oil-cooling for the pistons of the 4-cycle engines. In the 4-cycle boats of *U. 81-90* class, water-cooling, however, is being fitted experimentally for the pistons.

Both the 4-cycle and 2-cycle engines are reversible, but apparently, in practice, in the 2-cycle boats manœuvring is usually effected with the main motors, whereas in the 4-cycle type the main engines are always used for manœuvring.

The 2-cycle boats are generally the faster.

U. 70 and *U. 50* may serve as examples of the two types. The revolutions in these boats are approximately as follows:—

	<i>U. 70</i> (2-cycle).	<i>U. 50</i> (4-cycle).
Utmost speed	350	450
Full speed	300	350
Three-quarter speed	250	300
Half-speed	200	250
Slow speed	160	200
Dead slow	90	80

Horse Power and Speed.

	Utmost Speed.	Corresponding H. P. (two engines).
<i>U. 70</i>	17.5 knots	2,600
<i>U. 50</i>	15.5 knots	2,000

Cruising Speed.

U. 70 is reported to make her passages at 250 revolutions, giving a speed of 12.5 knots.

U. 50 when on passage apparently also proceeds at about 250 revolutions, giving, in her case, a speed of 8.5 knots.

Main Motors.

Are mostly supplied by the Allgemeine Elektrizitätsgesellschaft (A. E. G.). No essential change in the type has been made from *U. 19* onwards, but the switch-board has been much simplified and improved. In all cases there are two armatures fitted in tandem on the same shaft as, and abaft, the main engines.

The following are approximately the number of revolutions made by the main motors of *U. 70* and *U. 50*:—

	<i>U. 70.</i>	<i>U. 50.</i>
Utmost speed	300	350
Full speed	250	300
Three-quarter speed	200	240
Half-speed	150	180
Slow speed	100	120
Dead slow	85	90
Slowest possible	20	20

When on the surface the motors are available as generators for charging the battery, being run off the main engines.

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Sub-
marines.

Clutches are fitted between the engines and motors and between the motors and propellers. The clutch between the engines and motors, known as the Bamag clutch, is worked by compressed air, with alternative hand gear.

Fuel.

As mentioned above, the earlier submarines used paraffin. From *U. 19* onwards all German submarines used, if possible, heavy oil of a specific gravity of about 0.9. They are, however, not dependent on this, but can use any oil which is not too viscous, and which has a flash point over 100° Fahr.

The oil fuel usually employed is a first distillate of tar oil, and is of a brownish colour.

In *U. 70*, with engines developing 2,600 h. p. at full power, the consumption of oil at 12 knots is about 60 gallons an hour: at 8 knots it would be about 20 gallons an hour.

On long cruises, oil is carried as a matter of routine in two or more of the water-ballast tanks; in most modern submarines four ballast tanks are appropriated for this purpose, the oil, as used, being replaced by salt water, as in the case of the fuel tanks proper.

The amount thus carried has been included under "Fuel Stowage" and allowed for in the "Radius of Action" given in the tabulated details on pp. 2-9.

The figures given in the "Radius of Action" column represent ordinary cruising with both engines. They can be exceeded by using one engine only.

Accumulators.

All boats appear to carry a battery of 220 cells, divided electrically into half batteries or quarter batteries. They are placed in tanks below the living quarters both before and abaft the control room. Airtight flooring with traps in it is fitted over the tanks. Very elaborate ventilation arrangements are fitted to get rid of the hydrogen produced when charging the accumulators.

The plates are of the grid type filled with the usual pastes; about 16 negative and 15 positive plates in each cell.

The dimensions of the cells are various, being modified as necessary to suit the place of stowage.

The life of the accumulators depends mainly on the regularity with which charging is carried out. If it can be avoided, the battery is never allowed to remain for long in a half-charged condition, as in this state the plates rapidly deteriorate.

The battery can be charged in case of necessity from almost any vessel fitted with a dynamo, as well as from a shore-charging station.

Complete charging of the battery takes from 18 to 20 hours, but the ordinary charging up carried out at sea will rarely extend beyond six hours. A submarine is not obliged to complete charging before she submerges; if charging is incomplete, this will merely mean a proportionate reduction of her radius of action when submerged.

The voltage in all boats is 220.

Propellers.

Two 3-bladed propellers are fitted to all boats; diameter in *U. 66-70* class about 5 feet.

Auxiliary Machinery.

Practically all electrical. Includes H. P. and L. P. air compressors, gyro and wireless alternators, capstan, periscope, steering and fan motors, ballast pumps, fuel pumps, and lubricating oil pumps.

The main ballast pump is designed for use up to a depth of 33 fathoms.

Exhaust Funnels.

All submarines up to *U. 18* were originally fitted with conspicuous exhaust funnels aft. These have been replaced in most cases by smaller funnels set at an angle of about 30° to the deck, pointing aft. The exhaust from these boats may be visible at a considerable distance.

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marines.

Upright funnels are, however, sometimes used as a means of disguise or concealment, dense smoke being then purposely emitted.

All modern submarines exhaust through a pipe at the stern just above the water line, and their exhaust is almost invisible.

Submersion.

The compensating and trimming tanks are always kept adjusted so that to submerge only the external ballast tanks have to be filled. At the same time the main motors are started ahead to force the boat under by means of the hydroplanes.

Emersion.

The main ballast tanks are blown partially empty by means of compressed air from the air storage bottles. When connection with the atmosphere has been established, the ballast tanks are completely emptied either by the pumps or by compressed air.

When a submarine dives quickly a cloud of steam and black smoke may be observed, which is apt to convey a false impression that the submarine has been hit.

The black smoke is caused by fuel oil being discharged unconsumed into the exhaust pipe, the heat in which, combined with the absence of air, causes partial combustion. The white portion of the cloud is steam, due to the hot exhaust pipe coming into contact with the sea-water.

In addition, the venting of the tanks during submerging might possibly be mistaken for the fall of a shell.

Depth when Submerged.

Large submarines cruise at a depth of from 8 to 10 fathoms, but in heavy weather they go deeper; they make their attacks at a depth of from 3 to 4 fathoms, reckoning in each case to top of superstructure.

They lie on the bottom in depths up to 27 fathoms.

Cases are known of German submarines having dived to a depth of 50 fathoms without injury.

Diving Capabilities.

In areas in which patrol craft are frequently met with, German submarines usually proceed with one oil engine and the opposite main motor running for propulsion. They are thus ready for instant diving, and it is not necessary first to start the motors, as described above under "Submersion." The other main motor, on the same shaft as the oil engine which is in use, is run as a dynamo for charging the battery. In this manner the electricity expended is constantly replaced. Submarines can therefore proceed like this for an indefinite period.

As a further precaution some submarines proceed with the majority of their ballast tanks already flooded, so that the superstructure is awash and only the conning tower is visible.

Under such conditions a submarine can submerge within a minute to a depth of 3 fathoms (reckoned to top of superstructure).

Prize Crews.

Submarines making extended cruises have recently carried a prize crew of one or two officers and from four to seven men, additional to complement. These officers and men are used to man captured vessels, which are then employed as decoys or for housing crews of ships sunk.

U. 71-80.

General Remarks.

These large mine-laying submarines form a class apart; their main characteristics will, therefore, be briefly described, as far as information is available.

Endurance.

The usual duration of cruises is three to four weeks, but, owing to the low speed of these boats (9 knots), their radius of action is small compared with that of other ocean-going boats.

Deck and Superstructure.

These submarines have a good deal of freeboard.

The superstructure is rounded off on either side to meet the hull, so that the top of the tanks is not visible, except just in rear of the torpedo tubes, where the superstructure narrows up to leave room for loading the tubes.

The bow also is rounded.

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Part III. Periscopes.

Section 5. Two are fitted, the foremost one being used only from control room, the after one from either control room or conning tower.

Sub-marines. Armament.*Guns and Ammunition Supply.*

One 4.1-inch or 22-pr. gun, mounted about 25 feet before conning tower.

One machine gun.

Torpedo Tubes and Torpedoes.

Three deck torpedo tubes, two right forward and one right aft, the after one being on one side of the boat (it is uncertain which). They are built into the hull, only the breech and mouth being visible. They are loaded from on deck, but fired from conning tower. The safety pins of the pistols are usually removed on leaving harbour, so that there is no need to touch the torpedoes again.

Three 19.7-inch torpedoes are carried, stowed in the tubes.

Mines.

Thirty-four Type IV. mines are carried, stowed in a mine room right aft. The mines stow on their sides on three tiers of rails fitted on either side of the boat.

They are ejected by compressed air through two horizontal tubes, one on either side in the extreme stern, level with the lowest tier of rails. The mines in the upper tiers are transported down to the level of the tube by a small lift of some kind, probably worked electrically. The mines stow with the sinker aft, so that the latter enters the tube first.

Internal Arrangements.

The pressure hull is subdivided as follows:—

- (1) *Bow compartment*, containing the men's living quarters right forward, and abaft these, separated by a curtain, the petty officers' mess. An ordinary watertight bulkhead separates this from
- (2) The *warrant officers' mess*, a small compartment separated by a pressure-proof bulkhead from
- (3) The *officers' quarters*, separated by another pressure-proof bulkhead from
- (4) The *control room*, which again is separated by a pressure-proof bulkhead from
- (5) The *engine room*, separated by an ordinary watertight bulkhead from
- (6) The *motor room*, abaft which, separated by another watertight bulkhead, is
- (7) The *mine room*.

Watertight doors or manholes are fitted in all bulkheads.

Accommodation.

There are not enough bunks for the full complement, and a certain number of hammocks are provided.

Hatches.

There are three access hatches, one on top of conning tower, one just before the gun, leading to warrant officers' mess, and one aft, leading to motor room. Abaft this there is a specially large hatch used for the passage of mines only.

Compasses.

A magnetic diving compass is fitted on fore end of fairwater, and the corresponding compass below it in the control room.

In addition there is a gyro installation, consisting of a master compass in motor room and repeaters in control room and conning tower.

Anchor Gear.

A stockless anchor is carried in a hawse pipe forward.

Sounding Gear.

A hydro-pneumatic sounding machine, worked electrically, is fitted in control room.

Wireless Telegraphy.

A silent cabinet is fitted on starboard side of engine room.

II.—COASTAL TYPE ("B." BOATS).**U.B. 18-47.**

(See Plates 88 and 89.)

General Remarks.

These submarines form practically one class, though there are a few small differences between *U.B. 18-29* and *U.B. 30-47*.

Submarines of this type are constructed in sections, so as to be transportable by rail or otherwise. They have only a single hull, but light external tanks are fitted. They are much more vulnerable to gunfire than the ocean-going type, the conning tower, as stated below, being a particularly vulnerable point. A striking feature, which at once distinguishes them from the ocean-going type, is the bluff, rounded bow and very low stern—the latter nearly submerged when in surface trim.

Colour.

A light French grey, as in the case of ocean-going submarines. Waves painted on the hull and superstructure, and even on the bridge screen, are a favourite device. The deck is often painted dark grey or black.

Endurance.

The usual length of cruises is from two to four weeks.

General Construction.

These submarines are 119 feet long overall and 14 feet 8 inches broad over rubbers. The pressure hull is about 88 feet long with a maximum breadth of 12 feet. The sections of the pressure hull are circles. The length and breadth beyond the pressure hull are obtained by building light steel casings at the ends to give the submarine ship-shaped extremities, and by fitting external saddle tanks, which carry water ballast amidships and oil fuel towards the ends. These casings and tanks are about $\frac{3}{8}$ inch thick.

The pressure hull plating is $\frac{1}{8}$ inch thick, worked flush on the frames with external edge strips. The frames are 31 inches apart and of angle-bulb section 6 inches deep.

The pressure hull is built in 5 sections connected together by external strips running round the boat and double riveted on each side of the joint. The middle section, about 29 feet long, is a cylinder. The other four sections are roughly frustrums of cones. The lines of the pressure hull are therefore all straight and the ends are blunt. The few internal tanks are placed so that they do not cross the junctions of the pressure hull. This permits all the sections to be built complete with their tanks, and the latter to be tested in the sections. The whole is then ready for transport, if necessary, by rail and for re-erection on arrival at its destination. This re-erection can easily be carried out in a fortnight, the various internal fittings being then quickly installed.

The superstructure, saddle tanks, external casings and keel are put on after the sections of the hull have been connected up.

Keel.

The ballast keel runs nearly the whole length of the pressure hull. It is 4 feet wide and 12 inches deep, formed of strong transverse girders and bottom with thin casing at the sides. Lead pigs are stowed along the keel.

The centre part of the keel forms a detachable safety weight.

External Tanks.

There are four broadside ballast tanks, two on either side of the submarine, amidships. The extremities, beyond the pressure hull, are free flooding. The broadside fuel tanks, four in number, are situated one before and one abaft the ballast tanks on either side; capacity 17 tons.

Internal Tanks.

The trimming tanks are situated at the extreme ends of the pressure hull. In addition, there are six main internal tanks, three on each side of the middle line. The two after tanks, which are under engine room, stow 5 tons of oil fuel. The other four, under the control room and fore end of engine room, are ballast and compensating tanks holding 14 tons in all.

Part III. Section 5. Submarines. Deck and Superstructure.

The superstructure stands about 3½ feet above the pressure hull and is open to the sea through numerous small holes on either side. It contains fuel and air supply connections, air bottles, engine muffler boxes, sounding machine, and various safety arrangements, such as telephone and light buoy, lifting shackles, and diver's connections. The plating is about ½ inch thick. The breadth at ends is about 3 feet, but this increases in wake of gun, conning tower, and engine hatch, so that amidships a fairly roomy upper deck is obtained. The deck is formed of wooden gratings and steel frames, and is generally portable throughout the whole length.

Net Cutter.

A net cutting device is fitted to a number of boats of this type. It consists of a species of saw edge slanting upwards and aft from the top of the stem, and a similar arrangement slanting downwards and aft from the bottom of the stem. The length in each direction is about 10 feet.

The saw edges are formed by separate knives or teeth, about 2 inches wide and 1½ inches in depth, set in an iron plate. Stays are fitted on either side, to the deck in one case and to the boat's bottom in the other.

Conning Tower.

Circular and about 4½ feet in diameter, the casting being in two parts connected by horizontal flanges. A light bridge is built over it, with surface-steering position at fore end.

The conning tower contains a glass gauge tube to show level of water outside, depth gauge, clinometer, engine telegraphs, torpedo firing pistols, gyro receiver, steering wheel, &c. A circular watertight hatch is fitted to top of conning tower as in ocean-going type, but there is no hatch shutting off the conning tower from pressure hull. There is a large opening in pressure hull to allow of communication, and consequently a single hole in the conning tower should suffice to prevent the boat from diving.

These submarines are apparently fought from the conning tower.

Circular side lights, 3 inches in diameter and provided with hinged deadlights, are fitted in the sides of the conning tower.

A fairwater is fitted round the conning tower as in ocean-going type, but not so pointed.

Periscopes.

Two are carried, one in conning tower, one in fairwater just abaft it. The forward one, used either from conning tower or from control room, is bifocal, 1.5 and 6 powered. The tube is 2.4 inches in diameter at top, 5.9 inches at the bottom, and 21 feet 4 inches in length. The after one, used from the control room only, is 3.3 inches in diameter at top, 5.9 inches at bottom, and also 21 feet 4 inches in length.

Only crude deflection scales are arranged for.

A motor is fitted for raising each periscope. The drums on which the periscope-raising wires are wound can be worked by hand if necessary.

An electric flashing lamp is fitted on one of the periscopes.

Armament.**Guns and Ammunition Supply.—**

One 22-pr. (8.8-cm.) gun is fitted just before the conning tower. A "ginger-beer bottle" tampion is fitted. There is a small ready-use magazine in the superstructure on fore side of the gun. The main supply of ammunition is stowed under the torpedo room forward, and is passed up by hand through the conning tower. The normal stowage is about 120 rounds.

One or possibly two machine guns are carried, two positions being provided on the bridge.

Torpedo Tubes and Torpedoes.—

There are two 19.7-inch torpedo tubes, one above the other, in the bow. They are fired electrically by air impulse, but the firing valves can be worked by hand if necessary. The tube is built in three lengths, the rear length alone being inside the pressure hull. The centre length is a short one, a slack fit round the torpedo, with

Part III. Section 5. Submarines.

guides to keep the torpedo central, and this length passes through the fore end of the pressure hull. The outer length is carried by the external bow casing. One side of the stem is cut away as far as the end of the tube itself, the other side being left presumably to protect the bow caps.

Two firing reservoirs are fitted to each tube, the maximum working pressure being 500 lbs. per square inch.

Four torpedoes are carried, two in the tubes and one on either side abaft the tubes. Their length is 19 feet 8 inches. The head contains a charge of about 320 lbs. of explosive, apparently T.N.T. They are of the dry heater type and are fitted with gyroscopes capable of being angled in 15 steps up to 90°.

Torpedo net cutters are carried.

Internal Arrangements.

Four main watertight bulkheads are fitted. Two of these are amidships and form the ends of the control room, which is immediately under the conning tower. The other two are near the bow and stern and, together with the ends of the pressure hull, serve to form the trimming tanks.

Before the control room are living quarters and the torpedo room. Aft the control room is the engine and motor room.

Fresh water tanks are in the forward compartment under the torpedoes, and the batteries are under the living quarters.

The control room, which is very cramped, contains all the usual mechanism (see under Ocean-going type, page 24).

Hatches.

Two access hatches are fitted in pressure hull, trunked up to the level of the superstructure top, one before the gun leading to the torpedo room, one just abaft the conning tower leading to engine room. In addition a torpedo hatch, set at about 25° from the horizontal, is fitted immediately before the foremost of these two hatches.

Compensating Tanks.

Are fitted inside pressure hull as in Ocean-going type (see page 21).

Compasses.

An Anschütz gyro compass installation is fitted, consisting of a master compass in after part of machinery compartment, one receiver on bridge and one in control room. A magnetic compass is fitted on bridge.

Steering and Hydroplane Gear.

The rudder is 32 square feet in area, the after hydroplanes 16 square feet each, and the forward hydroplanes 15 square feet each. They are all worked by manual power. There are three steering positions, one on the bridge, one in the control room, and one right aft by the master compass. The hydroplane pedestals are the fore end of the control room. Elaborate guards are fitted to the hydroplanes.

Anchor Gear.

One stockless anchor is carried in hawse pipe in superstructure forward stowing vertically. When let go, it passes through an opening in starboard hydroplane guard. Wire on drum in superstructure, with indicator inside hull. The motor for working it is in torpedo room.

Sounding Gear.

Machine fitted in forward superstructure just before conning tower. The lead is paid out through a pipe running vertically down through external main ballast. The depth is obtained by means of a sensitised tube carried in the lead.

Sound Signalling Apparatus.

For receiving apparatus, see Ocean-going type, page 25.

No sending apparatus is fitted.

Jumping Wires.

As in Ocean-going type (see page 25).

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Part III.
Section 5.
Sub-
marines.

Wireless Telegraphy.

A small W/T set is fitted in a box about 4 feet by 2 feet by 1½ feet in the control room. There is no silent cabinet. In the earlier boats of this class two hinged masts were originally fitted, raised from inside hull by screw gear and wire tackles, worked by electric motor or, alternatively, by hand. They were of steel tube, 28 feet long, tapering from 5 inches to 2½ inches.

The jumping wires were used as an auxiliary aerial when the submarine was trimmed ready for diving and when the masts could not be raised.

In several, if not all, cases the masts have now been removed, and only the jumping wires are available as an aerial.

Air Service.

Four large air bottles are carried outside the pressure hull in after super-structure. Capacity of each bottle: 13¼ cubic feet.

Two small bottles are fitted abreast each engine for blast and starting purposes. All blows are fitted in control room. The internal tanks are fitted with a relief valve, and the external with differential gauge.

Ventilation.

As in Ocean-going type (see page 26).

Provision is made for long periods of submersion and four oxygen cylinders are installed.

Safety and Salvage Arrangements.

As in Ocean-going type (see page 26).

Accommodation.

There are 12 bunks in forward compartment for a total complement of three officers and 18 men. This compartment is lined with mahogany. Men and officers are all together. The accommodation is rendered worse by the fact that, when cruising, the crew are strictly forbidden to go on deck except on duty, to prevent delay in diving.

Apparently there are no washing arrangements. 110 gallons of distilled drinking water and 880 gallons of other water are carried.

A few cupboards are provided for provisions and mess utensils. Twelve days' normal supply of provisions and three days' reserve provisions are carried.

Cooking is done on an electric stove. Steam heaters fitted with supply and exhaust connections on deck are fitted in each compartment.

Water closets are fitted aft, one for use on surface, one for use when submerged.

Main Engines (see Plate 89).

Two 6-cylinder, 4-cycle reversible Diesel engines; cylinders, 8¼ inches diameter, 9 inches stroke. Direction of revolution—counter clockwise. Bedplate is of bronze. Forced lubrication is fitted. Engines develop 142 H.P. each at 478 revolutions.

No main bearings are fitted between the pairs of cylinders, which is similar to motor car practice.

The compressor for starting air and engine fuel spraying is of the 2-stage tandem type, driven from a crank at the fore end of the crank shaft. The inter and after coolers are vertical and are embodied with the crank case of this compressor. The engines are connected to the main shafting by friction clutches which are incorporated with the fly wheels.

Main Motors (see Plate 89).

Made by Siemens-Schuckert. 125 H.P. each at about 220 volts and 416 revolutions. Each has two armatures in tandem on one shaft, the commutators being at the forward and after ends. Lowest possible speed, 20 revolutions; highest possible speed for short periods, 450 revolutions.

Fuel.

In all about 22 tons of heavy oil (specific gravity 0.9) is carried (normal stowage). If necessary, oil can also be carried in two of the external ballast tanks, giving an additional capacity of about 7 tons.

The consumption per hour at the full speed of 8½ knots is about 16 gallons, and at 5 knots about 5 gallons.

Part III.
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Sub-
marines.

Accumulators.

A battery of 112 lead cells is carried, stowed under metal screw-down covers in forward compartment amidships, and also in two rows at sides, each row forming a settee. Ventilation pipes are fitted to each cell.

The cells are about 39 inches high by 13 inches by 16 inches; weight about 816 lbs.

Each cell contains 20 positive and 21 negative plates.

The positive plates are solid, the negative plates of the grid type.

Capacity of battery, 3,260–5,300 ampère hours.

Propellers.

Two 3-bladed, 3 feet 9½ inches in diameter, 2 feet 4 inches pitch, projected area 4½ square feet. A guard is fitted outside each and is continued to support the outer end of after hydroplane pintle.

Auxiliary Machinery.

Air Compressors.—A 4-stage 2-crank compressor is driven by gearing from one of the main shafts; the inter-coolers are contained in a separate casting bolted to the hull. This compressor draws air from the boat and discharges to the H.P. system, and also to the suction side of a small 2-stage compressor driven from the other main shaft. This latter compressor is apparently used for topping up the torpedoes.

Other Auxiliary Machinery includes two main ballast pumps, two ready-use fuel pumps, and two lubricating oil pumps.

Lighting and Power Circuits.

Very simple. All cables used are braided only, no lead casing. Main fuzes carried at battery terminals with cables leading straight aft to motors. No switches anywhere except on open board over each motor for starting up, &c.

Diving Capabilities.

Submarines of this type are believed to be bad under-water craft.

The time required to submerge is reported to be 1 minute.

Two depth gauges are fitted, one graduated from 0 to 60 metres and one of large scale from 0 to 25 metres.

The hull is tested for a depth of 27 fathoms, but probably these boats rarely go to a greater depth than 16 fathoms.

For depth when cruising and when attacking, see under Ocean-going type, page 29.

U.B. 1–17.

(See Plate 86.)

General Remarks.

Constructed in sections, so as to be transportable by rail or otherwise. Several of them have been sent overland to the Mediterranean. They have only a single hull, and there are no external tanks. They are exceedingly vulnerable to gunfire.

In general appearance they are almost indistinguishable from the small mine-laying type, U.C. 1–15 (see page 41), but their length is about 20 feet less.

Colour.

As in U.B. 18–47 (see page 31). The German cockade—black, white, and red—is sometimes painted on either bow, looking like an eye. In combination with the fore hydroplane guards, which resemble fins, this produces the general impression of a whale's head.

Endurance.

The usual length of cruises is from 2 to 8 days.

General Construction.

Length overall: 90 feet; maximum beam: 10 feet. Length of pressure hull: 77 feet. The length beyond the pressure hull is obtained by light steel casings of ½-inch plate, built on so as to give the submarine ship-shaped extremities. Plating of pressure hull is ¼ inch thick forward, ⅜ inch thick aft. Distance between frames 30 inches.

Part III.
Section 5.
Sub-
marines.

The pressure hull is built in three sections. Probably the two after sections resemble those of type U.C. 1-15 (*see* page 41); the foremost section is entirely different in internal arrangement, but the bow is very similar in shape.

Keel.

The ballast keel runs the length of the pressure hull. The centre portion, 4 tons in weight, is detachable.

Tanks.

General arrangement is believed to be the same as in U.C. 1-15 (*see* page 42), small torpedo compensating tanks being fitted in place of mine compensating tanks. The normal stowage of oil fuel is 2.4 tons.

Deck and Superstructure.

Generally the same as in U.C. 1-15 (*see* page 42), the openings for the mine tubes forward, of course, being absent.

Conning Tower.

Believed to be exactly the same as in U.C. 1-15 (*see* page 42). There is no means of shutting off the conning tower from the hull.

Periscope.

One is fitted in the conning tower and can be used also from control room. A motor of about 4 H.P. is fitted for raising it.

Armament.

Guns and Ammunition Supply.—

One 1-pr. or a machine gun is carried, the 1-pr. being mounted before the conning tower.

Torpedo Tubes and Torpedoes—

Two 19.7-inch torpedo tubes in the bow.

Two torpedoes are carried in the tubes; no reserve of torpedoes.

Internal Arrangements.

The control position is in the centre, below the conning tower. On the fore side are the living quarters, forward accumulators, and torpedo room; on the after side the after accumulators and engine and motor room. The ends of the submarine, beyond the pressure hull, form the trimming tanks.

Compasses.

A complete Anschütz gyro installation is fitted. A magnetic compass is also carried in reserve.

Steering and Hydroplane Gear.

Believed to be generally the same as in U.C. 1-15 (*see* page 43).

Anchor Gear.

Believed to be similar to that in U.C. 1-15 (*see* page 43).
The weight of the anchor is 3 cwt.

Sounding Gear.

Believed to be the same as in U.C. 1-15 (*see* page 43).

Sound Signaling Apparatus.

Receiving apparatus, believed to be the same as in U.C. 1-15 (*see* page 44).
No sending apparatus is fitted.

Jumping Wires.

As in Ocean-going type (*see* page 25).

Wireless Telegraphy.

The arrangements are believed to be the same as in U.C. 1-15 (*see* page 44).

Part III.
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marines.

Air Service.

Believed to be similar to that in U.C. 1-15 (*see* page 44), but the position of the air bottles is not known.

Ventilation.

As in Ocean-going type (*see* page 26).

Capacity of ventilating fan 2,650 cubic feet per hour.

Two oxygen cylinders are carried, capacity 11 gallons each.

Safety and Salvage Arrangements.

Generally the same as in Ocean-going type (*see* page 26).

Accommodation.

Very cramped, and rendered worse by the fact that, when cruising, the crew are strictly forbidden to go on deck except on duty, to prevent delay in diving.

118 gallons of fresh water are carried. Cooking and heating arrangements as in U.C. 1-15 (*see* page 44).

Main Engines.

One Daimler or Körting reversible Diesel engine of 60 H.P. running at 540 revolutions. Capacity for water-cooling, 440 gallons per hour.

Main Motors.

Two armatures fitted in tandem on one shaft; 120 H.P. at about 210 volts and 630 revolutions.

A maximum speed of 8.4 knots can be attained on the surface with main motors, as against a maximum of 6.5 knots with the main engines.

Fuel.

Normal stowage 2.4 tons of heavy oil (specific gravity about 0.9). This stowage can not be much increased, as there are no external tanks. The consumption per hour at the full speed of 6½ knots is about 3 gallons, and at 5 knots about 1½ gallons.

Accumulators.

112 Tudor lead cells are carried, stowed partly before and partly abaft the control room.

Dimensions of the cells:—Length 10 inches, breadth 12½ inches, depth 24½ inches. Weight of a cell with its connections 321 lbs. Ventilation pipes are fitted to each cell.

Propeller.

One—3-bladed.

Auxiliary Machinery.

Includes air compressors, fan, capstan and periscope motors, main ballast pump, fuel and lubricating oil pumps, practically all of which are electrically driven.

III.—MINE-LAYING TYPE ("C." BOATS).

U.C. 16-79.

(*See* Plate 90.)

General Remarks.

This class of submarine represents a very great advance on *U. C. 1-15* (*see* p. 40), and in endurance and radius of action closely approaches the Ocean-going type. The general idea of the *U. C. 1-15* class has been followed, but the single hull has been abandoned in favour of a double hull; the dimensions and engine power have been considerably increased, and the interior is divided into 7, instead of 3, watertight compartments.

There are slight differences between submarines built in different yards, but one general description will serve for the whole class.

Mine-laying Methods.

When in the vicinity of the coast, submarines almost invariably lay their mines at night, and, when in moderate depths, always endeavour to lay them at high water so as to have ample depth for diving.

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marines.

Their cruises are, as far as possible, arranged for dates when high water will occur during hours of darkness in the locality which they visit. Apparently they do not object to moonlight, which enables them to see their whereabouts, though it also exposes them more to attack.

Whilst laying their mines they proceed either on the surface or submerged, according as our patrols are active or the reverse. When laying mines on the surface they usually proceed at half-speed, about $6\frac{1}{2}$ knots.

The mines are laid most frequently in groups of 6 or 12.

These submarines depend greatly upon light vessels and conspicuous landmarks for obtaining their position when they are about to lay mines.

Out Voyage.

Submarines carrying mines do not hesitate to attack merchant vessels which they may happen to meet whilst proceeding to their proper objective, but they do not go out of their way to search for prey until they have laid their mines.

Return Voyage.

Is usually made along the trade route.

But, after laying his mines, the submarine commander has considerable discretion in his further operations. Minelaying submarines, however, always endeavour to keep out of the way of men-of-war, unless they happen to find themselves in a favourable position for firing a torpedo.

Endurance.

The usual length of cruises is from one to three weeks, but these submarines are capable of keeping the sea for longer periods. One boat of the type is believed to have spent 55 days continuously at sea.

Colour.

The bottom is painted black, the rest of the hull light grey; the tops of the tanks are painted black.

General Construction.

Double hull, like the ocean-going type of submarine (*see p. 20*). The inner hull is built in three or more sections.

Deck and Superstructure.

The fore part of the deck is raised about 4 feet to give the extra height required for the mine tubes, each of which contains three mines, one above the other. This gives the appearance of a fore-castle.

From the after end of this raised portion to near the stern a superstructure is fitted; it is about 18 inches above the tops of the tanks.

Net Cutter.

In a number of cases the same arrangement is fitted as in U.B. 18-47 (*see p. 32*).

Boat.

A small canvas boat is stowed in a locker forward above the mine room.

Conning Tower.

Circular in section, about $4\frac{1}{2}$ feet in diameter and 6 feet in height.

It is unarmoured, and there are no means of shutting it off from the control room below it. A grating is fitted over the opening in the hull.

The top of the conning tower is fitted with a steel or metal weather screen on fore side.

Periscopes.

Two are fitted, the foremost one being used only from control room, the after one from either control room or conning tower. They are 20 feet 4 inches in length; diameter of lower tube 5.9 inches. Worked by motor, with alternative hand gear.

Steaming light and a flashing lamp are fitted to one of the periscopes.

Armament.

Guns and Ammunition Supply.

One 22-pr. gun, on fixed mounting, before conning tower.

One machine gun.

Normal stowage of 22-pr. ammunition, about 120 rounds, but this is often considerably exceeded.

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marines.

Torpedo Tubes and Torpedoes.

There are three 19.7-inch torpedo tubes, viz., two deck tubes right forward, built into the hull, with only the breech and the mouth showing, and one submerged tube right aft, amidships. The deck tubes are fitted with bow caps.

As a rule, three torpedoes only are carried, stowed in the tubes; stowage is provided for a spare torpedo, but it has to be taken apart and stowed in three sections in the three after compartments of the boat, to allow the watertight doors to be closed.

The two upper tubes are loaded from on deck, but fired from conning tower or control room. The safety pins of the pistols are usually removed on leaving harbour, so that there is no need to touch the torpedoes again.

Mines.

Eighteen Type IV. mines are carried, stowed in six mine tubes right forward, three in each tube, one above the other. These tubes, which are about $3\frac{1}{4}$ feet in diameter, are placed on the middle line and are inclined aft from top to bottom.

Releasing gear, worked by hand, is fitted to enable each mine to be dropped separately, and interlocking gear is added to prevent one of the upper mines being released before the mine or mines below it. The arrangements are similar to those in U.C. 1-15 (*see p. 43*), except that there are three sets of levers, instead of two, fitted to each tube.

The mines are released by these submarines both when on the surface and when submerged.

Internal Arrangements (*see Plan 90*).

These boats are sub-divided as follows:—

- (1) *Mine room*, right forward, separated by a watertight bulkhead from
- (2) *living quarters*, separated by a pressure-proof bulkhead from
- (3) the *control room*. The after part of this, separated by a light bulkhead, which extends only to floor of control room, forms
- (3a) a small *auxiliary machinery compartment*, separated by a pressure-proof bulkhead from
- (4) *living quarters*, separated by a watertight bulkhead from
- (5) the *engine and motor room*, forming one compartment, abaft which, separated in each case by a watertight bulkhead, are
- (6) a small *petty officers' mess* and
- (7) the *after torpedo room*.

Watertight doors, about 5 feet in height, are fitted in mine-room bulkhead and in both engine-room bulkheads; in the other bulkheads watertight manholes are fitted, about 4 feet in diameter.

In some boats of the type the officers' and warrant officers' quarters are forward and the men's quarters are aft; in other boats this arrangement is reversed; the officers' and warrant officers' messes are separated by a curtain.

Hatches.

There are three access hatches: one on top of conning tower, one just abaft mine room, leading to warrant officers' mess, and one aft, leading to engine room. The after hatch also allows of the passage of torpedoes.

Compasses.

A magnetic diving compass is fitted on the fore end of the fairwater, and the corresponding compass below it in control room.

In addition, there is a gyro installation, the master compass being fitted in the control room, one repeater in the conning tower and another right aft in torpedo room. It is found that the gyro compass cannot be relied upon in heavy weather.

Steering and Hydroplane Gear.

Two vertical rudders, of the balanced type, are fitted. The vertical rudders and foremost hydroplanes are worked electrically, the after hydroplanes by hand.

These submarines are practically always steered from the control room. There is no steering position in the conning tower, but there is a gyro repeater just below conning tower hatch for the convenience of the captain or officer of the watch. The deck steering position, which is on fore end of fairwater, is seldom used.

Anchor Gear.

A mushroom-head anchor, worked by an electric capstan, is fitted right in the bow. Weight, 660 lbs. The cable consists of about 55 fathoms of .79-inch chain.

Part III. Sounding Gear.**Section 5.****Sub-**
marines.

A hydro-pneumatic sounding machine, worked electrically, is fitted in the mine room. It appears to be of the same pattern as in *U.C. 1-15* (see p. 44). It is not found to be very reliable, and the hand lead is preferred.

Navigation and Signal Lights.

Steaming light is fitted on periscope, side lights on conning tower.

An anchor light is fitted for lighting upper deck, and there is a shaded stern light, which can be used for flashing and can be dimmed when necessary by inserting a resistance. Morse key and resistance are in conning tower.

Sound Signalling Apparatus.**Receiving Apparatus.**

Three microphones are fitted in the external tanks, one right forward, the others one on either side amidships. By means of a 3-way switch each of the microphones can be connected in turn to a telephone head-set in the wireless cabinet, thus enabling the direction of vessels to be roughly determined.

By inserting resistances in parallel with the circuit, interference due to sounds in the boat can be reduced, but the apparatus is reported not to be really reliable unless the engines and all auxiliary machinery are stopped.

No *Sending Apparatus* is fitted.

Jumping Wires.

Fitted as in Ocean-going type (see p. 25), and available as an auxiliary aerial.

Wireless Telegraphy.

One hinged mast is fitted aft by engine room hatch. The aerial leads forward to the bow.

A good-sized silent cabinet is fitted at after end of mine room, on the port side.

In the North Sea these submarines generally confine their use of their wireless telegraphy installation to listening.

Ventilation.

The general system is the same as in Ocean-going type (see p. 26).

Accommodation.

Twenty-three bunks are fitted, *i. e.*, one for each officer and man in the complement.

The living quarters are wood-lined, but are nevertheless said to be very damp.

An electric cooking stove is fitted on starboard side of mine room, opposite the wireless cabinet. There are four electric heaters, and steam heaters are fitted in all compartments for use in harbour.

At sea, men are only allowed on deck with special permission, to prevent delay in diving.

There are two water-closets, one forward on starboard side of mine room, and one as a reserve fitting, in control room. They are merely curtained off, and, as a rule, are only used when submerged.

Main Engines.

Two six-cylinder, four-cycle, reversible Diesel engines of 300 B.H.P. each at 450 revolutions. Diameter of cylinders $10\frac{1}{4}$ inches, stroke 12.6 inches. The crank shaft is in one piece with cranks 120° apart.

Main Motors.

Two of about 115 H.P. each at about 230 volts and 365 revolutions. Highest possible speed for short periods 445 revolutions.

Fuel.

The normal stowage is about 40 tons in two pairs of tanks, holding 5,319 and 4,785 gallons respectively. Additional oil can be carried in the ballast tanks if required.

Lubricating Oil.

Six tons are carried. A first distillate of tar oil is usually employed.

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marines.**Accumulators.**

124 cells. Dimensions of each cell: length 20 inches, breadth $13\frac{1}{2}$ inches, height 28 inches, weight 776 lbs. Weight of complete battery 43 tons, *i. e.*, about 320 lbs. per H.P.

Capacity from 3,260 ampère hours at the two-hour rate to 5,300 ampère hours at the twenty-hour rate.

Propellers.

Two, of manganese bronze—

	<i>U.C. 39.</i>	<i>U.C. 31-33.</i>
Diameter	4 feet 2.8 inches.	4 feet 3.2 inches.
Pitch	3 feet 6.5 inches.	3 feet 0.4 inch.
Area	4.22 square feet.	5.7 square feet.

Auxiliary Machinery includes—

Capstan motor of 14 H.P. at 1,200 revolutions.

Main air compressor with capacity of 8 litres (.28 cubic foot) to 200 atmospheres per minute.

Auxiliary air compressor with capacity of 5 litres (.18 cubic foot) to 160 atmospheres per minute from initial pressure of 40 atmospheres.

Main ballast pump driven by 14-H.P. motor at 1,900 revolutions, delivering 110 gallons per minute against a head of 197 feet.

Trimming pump—of same capacity as above.

Periscope motor of 5-H.P., which can raise or lower periscope at rate of 8 inches per second.

Usual Depths.

These submarines usually proceed at a depth of 8 to $10\frac{1}{2}$ fathoms when cruising, and at a depth of about $2\frac{1}{2}$ fathoms when making an attack, the depth in each case being reckoned to upper part of bow.

The minimum safe depth to dive in is considered to be about $8\frac{1}{2}$ fathoms.

U.C. 1-15.

(See Plates 86, 91, 92, 93, and 94.)

General Remarks.

Properly speaking, this series is divided into two classes, *viz.*, *U.C. 1-10* and *U.C. 11-15*, but the differences are so slight that a general description will serve for both.

These boats are built solely for mine-laying. They have only a single hull and no external tanks. They are exceedingly vulnerable to gunfire anywhere, but particularly in the conning tower.

They are easily transportable by rail, and several of them have been sent overland to the Mediterranean. *U.C. 12*, which commissioned at Bremen on 2nd May 1915 and was paid off at Kiel on 4th June 1915, was despatched from Kiel by rail on 22nd June, arrived at Pola on 24th June, and was assembled and ready for sea on 27th June 1915.

Minelaying Methods.

Similar to those of *U.C. 16-79* (see page 37).

The 12 mines carried are sometimes laid in close proximity, but more usually in groups of from 4 to 8. Sometimes they are laid singly.

Except when laying their mines, these submarines apparently always proceed on the surface until forced to dive to avoid detection or escape an attack. When laying mines they are usually submerged and proceeding at a speed of about 2 knots.

Endurance.

The usual duration of cruises is from two to five days.

Colour.

As in *U.B. 18-47* (see page 31).

General Construction.

The pressure hull is constructed in three sections, of which the foremost and after are about 43 feet, and the midship section about 24 feet in length. The foremost and

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marines.

midship sections are approximately cylinders, the after section is roughly a frustum of a cone, tapering considerably towards the stern. Ship-shaped extremities of $\frac{1}{8}$ -inch plating are built on to the pressure hull. The pressure hull is of $\frac{1}{16}$ -inch plating. The frames are bulb-angles $5\frac{1}{4}$ -inch by $2\frac{1}{2}$ -inch by $\frac{1}{8}$ -inch, and are spaced about 55 inches apart in foremost section and from 26 inches to 34 inches apart in the other two sections. The three sections are secured by bolted flanged joints, the flanges being $1\frac{1}{8}$ inches and bolts $1\frac{1}{8}$ inches; joining material, thin rubber.

Keel.

The keel is built of plate, filled in with 18 tons of pig iron. The center portion forms the detachable safety weight (about 3 tons).

The keel is about 3 feet 4 inches in width and 13 inches in depth. In wake of the mine tubes the keel bottom is discontinued, only the side portions being fitted.

Tanks (see Plate 93 (a)).

The small bow compartment, separated from the mine-room by a pressure proof bulkhead, serves as a ballast tank, capacity 8 tons of water. The other ballast tanks, two in number, capacity 13 tons, are under the control room.

The foremost trimming tanks are fitted on either side inside pressure hull right forward. The after trimming tank is situated at the extreme after end of the pressure hull.

The oil-fuel tanks, four in number, are under the main engines; capacity 2.3 tons in *U.C. 1-10*, 2.8 tons in *U.C. 11-15*.

Compensating tanks are fitted on either side of the control room, and also special mine compensating tanks on either side of the mine tubes in foremost section.

Deck and Superstructure.

A light superstructure extends the whole length of the boat. It is not connected directly to the hull plating, but to light brackets riveted to this. The side plates of structure to flood and drain freely and rapidly.

The fore part of the deck is taken up by the tops of the mine tubes. These are completely covered in by steel gratings.

The superstructure contains fuel and air supply connections, engine muffler box, sounding machine, and the usual safety arrangements.

Conning Tower.

Situated a little forward of the center of the hull. Circular in shape, with a diameter of $4\frac{1}{4}$ feet. It is constructed of $\frac{5}{8}$ -inch plating, flanged into hull, and has a cast steel dome. The plating is stiffened inside with one circumferential conning tower and hull. A hinged platform, cut away to allow of the passage of the periscope and mast, is fitted over the opening in the hull.

The conning tower contains depth gauge, clinometer, engine room telegraph worked by bicycle chains, voice pipe, periscope-raising switch, hatch-closing gear, and also a gauge graduated in kilograms showing residual buoyancy, presumably for use when trimming to show conning tower only above surface, &c.

A light bridge is built over the conning tower about 10 feet above water line, with steering position on the foreside; the usual fairwater is built round conning tower, and has embrasures to allow for looking ahead or astern through the four sidelights

Periscope.

A single periscope is fitted in conning tower and can also be used from control room below it. The tube is of delta metal, length over all 17 feet, diameter at bottom 5.9 inches, at top 3.4 inches. The periscope is bifocal—magnifications $1.5\times$ and $6\times$. Field of view 40° with magnification $1.5\times$.

The periscope is raised by an electric motor or alternatively by hand.

A range-finding attachment is fitted, as in Ocean-going type (see page 22).

Armament.

Two machine guns, sometimes only one, are carried. These can be mounted either on the bridge or on the platform immediately before conning tower. No torpedoes are carried.

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marines.

The main armament consists of 12 Type IV. mines, charge about 250 lbs. of T.N.T. These mines are stowed in pairs, one above the other, in six tubes which occupy practically the whole of the fore part of the boat. The tubes are about $3\frac{1}{4}$ feet in diameter and are placed on the middle line and inclined aft from top to bottom. Their inclination from the vertical varies from 25° to 28° , increasing from aft forward. It has been suggested that this may be due to the necessity for having the tubes long enough to contain two mines each, one above the other, without increasing the vertical dimensions of the submarine beyond the height available above the railway trucks when passing through tunnels.

Each mine is fitted with its own releasing gear, operated by hand, alongside the trunk. Elaborate interlocking gear is added to prevent the upper mines being released before the lower, &c.

The mines are always released when the submarine has headway, and usually when she is submerged, but they can be laid when on the surface if necessary.

Each mine, with its sinker, has a negative buoyancy of about 660 lbs. Accordingly, the submarine, when submerged, will be lightened by some $3\frac{1}{2}$ tons after laying the 12 mines. The mine-compensating tanks, six in number, can be filled separately as the mines are released.

Internal Arrangements.

The mine room, which is closed at the fore end by a curved and inclined pressure-proof bulkhead, occupies nearly the whole of the foremost section. There is just room for a man to pass round between the mine tubes and the mine-compensating tanks. Air and oxygen bottles are fitted between the mine tubes.

At its after end this compartment is closed by another curved, pressure-proof bulkhead, communicating by means of a watertight manhole with the control room.

The midship compartment contains living quarters and control room, the latter immediately under the conning tower. Underneath the living quarters, *i. e.*, both before and abaft the control room, are the accumulators, placed in iron tanks below watertight planking.

A light bulkhead, fitted in the after section, separates the engine and motor room from the control room; it is fitted principally to deaden the noise of the motors.

Hatches.

Besides the conning tower hatch there is only one access hatch; this is fitted in hull over after living quarters and trunked up to the upper level of the superstructure.

Compasses.

A complete Anschütz gyro installation is fitted with two receivers, one in control room and one for the bridge steering position. The master compass, with the gyro-motor generator, is situated at after end of engine room. There is also a portable magnetic compass for bridge.

Steering and Hydroplane Gear.

The vertical rudder is of the balanced type, cut away in the wake of the diving rudder, which is fitted abaft the propeller. The vertical rudder has a surface area of about 25 square feet, and the diving rudder about 19 square feet. The bow hydroplanes have a surface area of about 12 square feet each. The steering gear and hydroplane gear are worked on the Rapson's slide principle, by hand, and the forward and after planes can, by means of a clutch, be worked independently or together. The rudders or hydroplanes are well protected by guards. A portable steering wheel is fitted on the bridge; the only other steering position is in control room.

Anchor Gear.

A mushroom-head anchor, weight 3 cwt., is fitted in the small bow compartment. The cable consists of about 55 fathoms of $.63$ -inch chain.

The capstan, fitted right forward in superstructure, is worked by a motor inside hull.

Sounding Gear.

A hydro-pneumatic sounding machine, worked electrically, is fitted in superstructure just before conning tower. The lead is lowered straight over the side of the boat. The line consists of a rubber tube with an outer covering of plaited jute,

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marines.**

and the lead is hollowed to form an air-chamber. When sounding, a sufficient air-pressure is admitted to the tube to expel the water, and, when an equilibrium is reached, a gauge inside the hull registers the depth.

Sound Signalling Apparatus.

Receiving Apparatus.—

Two sets of microphones are fitted, one pair being placed in the ballast tanks aft, the other pair being placed in small tanks (about 8 inches wide) fitted to the inside of the hull, well forward, one on either side. The two microphones of the first set are merely intended to replace one another in case of accident. The second set is used for detecting the presence, direction, and course of other vessels. For this purpose the boat must be completely stopped, and no machinery allowed to run. The hull acts as a collecting surface for the sound waves, and they are communicated by the water in the tank to a small diaphragm on which the microphone is fitted. Either set of receivers can be connected to a single telephone head-set by means of a commutator. In addition, in the case of the second set, a port-and-starboard switch is fitted, enabling the listener to use the two microphones alternately and thus determine on which side of the submarine a vessel is. No very accurate directional results can be obtained but these submarines never rise to the surface until they have ascertained, by listening, that no vessel is moving in the vicinity.

No sending apparatus is fitted.

Jumping Wires.

As in Ocean-going type (see page 25).

Wireless Telegraphy.

A telescopic mast is fitted in the conning tower out of the middle line. When up, its height is about 26 feet above the water-line. The aerial consists of two wires leading both forward and aft, and has a total length of 55 feet. The feeder enters the hull through the fairwater abaft the conning tower through a porcelain tube. When the mast is lowered the slack wire is automatically drawn in, so that it is not necessary to disconnect the aerial when submerging.

The W/T set is a ½ k.w. Telefunken, quenched spark and valve receiving. No silent cabinet is fitted.

Apparently wireless telegraphy is very seldom used by these submarines.

Air Service.

Four steel bottles, for compressed air, are carried in forward compartment between the main tubes. A supply connection is fitted in hull above for charging these bottles from the land with compressed air at 2,275 lbs. per square inch. This operation occupies about 3½ hours. In addition the auxiliary compressor compresses the air, coming from the starting air bottle at 570 lbs. per square inch, to the required 2,275 lbs. per square inch, and discharges into the air bottles in mine room.

For further details, see Plate 93 (b).

Ventilation.

The general system is the same as in Ocean-going type (see page 26). The ventilating fan is in the engine-room. It takes its suction through two air-purifiers and also from overhead at each end of the boat. There are sluice valves connecting the fan suction with the battery vents. The discharge opens into the central compartment.

For further details, see Plate 94 (a).

Safety and Salvage Arrangements.

Are practically the same as in Ocean-going type (see page 26).

Accommodation.

Very cramped, and rendered worse by the fact that, when cruising, the crew are forbidden to go on deck except on duty, to prevent delay in diving.

For a total complement of one officer and 17 men only six bunks are fitted. Two or three hammocks are carried by way of further accommodation, but there is probably no room to sling them.

The living quarters and control room are lined with wood in two thicknesses with felt or horsehair between the two. Lockers, closed by leather flaps, are fitted in control room.

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marines.**

In *U.C. 1-10* 132 gallons, and in *U.C. 11-15* 200 gallons, of fresh water are carried.

Electric heaters are fitted, also electric cooking stove. In addition there are pipe radiators fed from the engine exhaust.

One water closet, which can be used when submerged, is fitted in engine-room.

Main Engines.

U.C. 1-10.—One 6-cylinder, 4-cycle reversible Diesel engine. Diameter of cylinders 6½ inches, stroke 9 inches.

U.C. 11-15.—One 4-cylinder, 4-cycle non-reversible Diesel engine. Diameter of cylinders 7½ inches, stroke 9.8 inches.

Air injection and air starting in both cases.

H.P. in both cases 80, at 500 revolutions.

The air compressor is driven direct off the forward end of the engine.

Exhaust through a muffler box in superstructure.

Between main engines and main motors is a friction clutch which operates on the inside of the fly-wheel rim. Between main motors and thrust bearing a claw coupling or dog clutch is fitted.

Main Motors.

Two armatures, fitted in tandem, on the same shaft as, and abaft, main engines. Shunt wound, separate yokes, with eight main and eight inter-pole windings each.

Working voltage 215, giving 175 H.P. for the two armatures, at about 620 revolutions.

A switchboard installed above the motors enables the two armatures to be connected in series or in parallel, and the batteries similarly.

Starting is effected without inserting a resistance. The number of revolutions is varied by regulating the field.

The motors can be run for prolonged periods by finely-graduated stages:—

On surface	-----	110 to 640 revolutions.
Submerged	-----	110 to 575 " "
Approximate number of revolutions with armatures in series and batteries in parallel	-----	100
Approximate number of revolutions with armatures in parallel and batteries in parallel	-----	200
Approximate number of revolutions with armatures in parallel and batteries in series	-----	400

By means of the clutches between engines and motors and motors and thrust block, the motors can be used for charging and engine starting, as well as propulsion.

As a generator, the two armatures in parallel can generate 550 ampères at 160 volts, running for prolonged periods at from 400 to 550 revolutions.

Propeller.

One 3-bladed propeller, diameter 3 feet 3 inches to 3 feet 6 inches; pitch, about 1 foot 5 inches.

Fuel.

Heavy oil, specific gravity about 0.9.

Fuel consumption at the full speed of 5.7 knots, 4 gallons per hour.

For system of connections, see Plate 94 (b).

Accumulators.

Placed in tanks, one at the forward end and one at the after end of the central compartment, forming the deck and seats in the living spaces.

In *U.C. 1-10* there are 220 cells, divided electrically into four groups of 55 cells each. Any one group can be used for the lighting. Each battery consists of two groups in series, and the batteries can be connected in series or in parallel for running the main motors.

The accumulators are made by Messrs. Tudor, of Hagen. Each accumulator contains 50 plates, 24 positive and 26 negative, and should have a voltage of 2.7. The plates are thinner in cross-section than those used in the British Service, and are about 3 feet by 18 inches.

The tops of the cells are built in and an elaborate battery-ventilating system is fitted, fresh air being conveyed in on one side and foul exhausted on the other.

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marines.

In *U.C. 11-15* there are only 112 cells in all, divided into two batteries of 56 cells each. Particulars are as follows:—

Dimensions of cells: 25 inches by 12.8 inches by 13.7 inches.

No. of plates: 18 positive, 19 negative.

No. of terminals: 6.

Weight of a cell: 432 lbs.

Total capacity of accumulators: 2,000-3,000 ampère hours.

Auxiliary Machinery.

Includes the following:—

- (a) Combined capstan and periscope-raising motor.

About 4.5 H.P. Fitted with a clutch, enabling it to be used for either of its two purposes.

- (b) Wireless telegraphy alternator.

A single-phase $\frac{1}{2}$ k.w. machine, situated abaft the main motors.

- (c) Gyro motor generator, situated right aft in the engine-room by master compass.

- (d) Ventilating fan motor, about 2 H.P.

Trunks fitted for ventilating both boat and battery.

- (e) Ballast pump and auxiliary compressor motor.

About 13 H.P., 110-160 volts, 1,560 to 1,850 revolutions. Used either for pumping out tanks and bilges or, by means of a clutch, for supplying compressed air to the bottles in mine room. This is the only motor-driven ballast pump.

The main air compressor, as mentioned above, is driven direct off forward end of main engines.

In addition, a bilge pump and a water-cooling pump are fitted to main engines, and a portable hand bilge pump is carried.

Lighting and Power Circuits.

The lighting voltage is 160.

All electric light fittings are made of brass, heavily nickelled, and the switches are watertight. All conductors heavily insulated.

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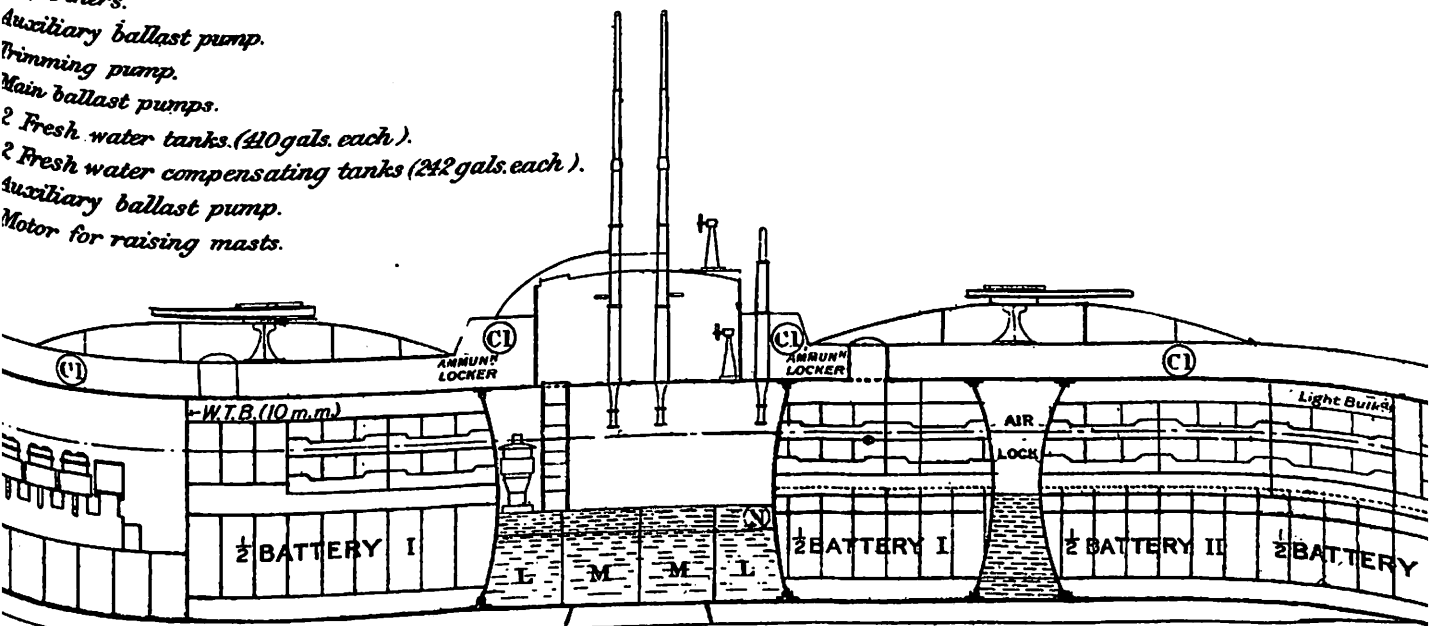
SUBMARINES U. 66 - 70 CLASS.

Drawing approximate only.

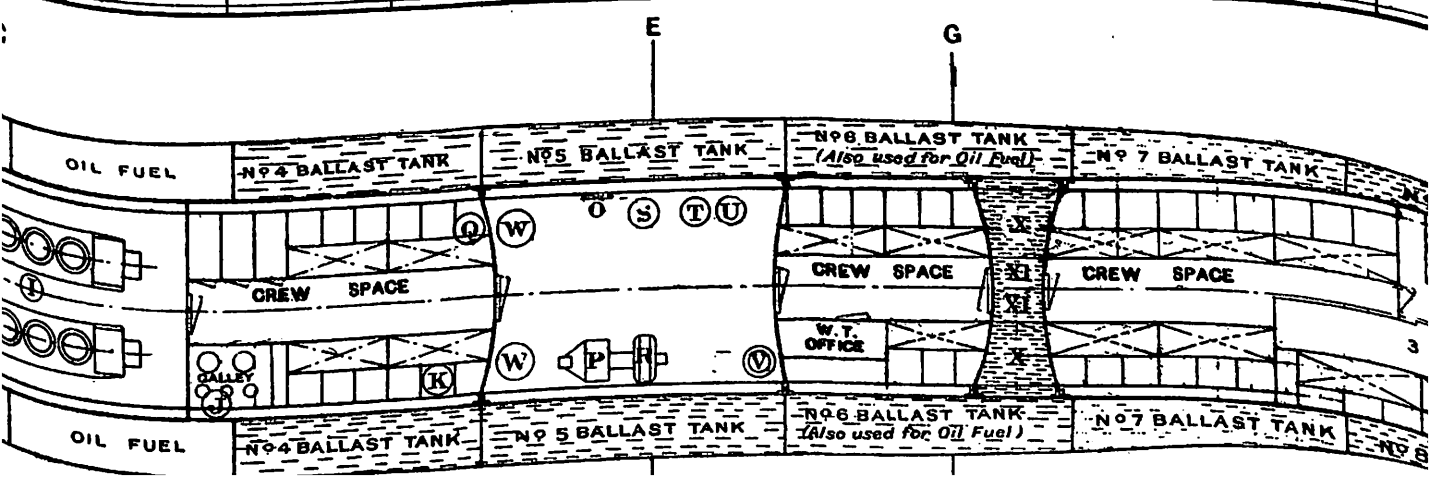
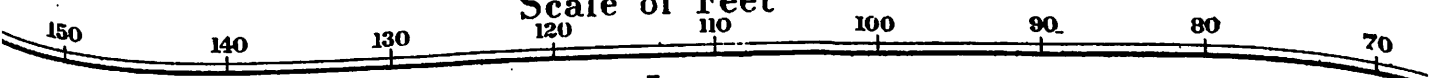
Total length, about 236' 0"
 Beam at midship section, about 21' 0"
 Draught including keel, about 12' 0"
 Displacement on the surface, about 800 Tons.
 submerged, about 1150

Armament: - 1-4 1" gun, or 2-22 pdr. guns (Drawing shows 2-22 pdr. guns).
 5-Torpedo tubes, 19-7" (4 Forward and 1 aft).

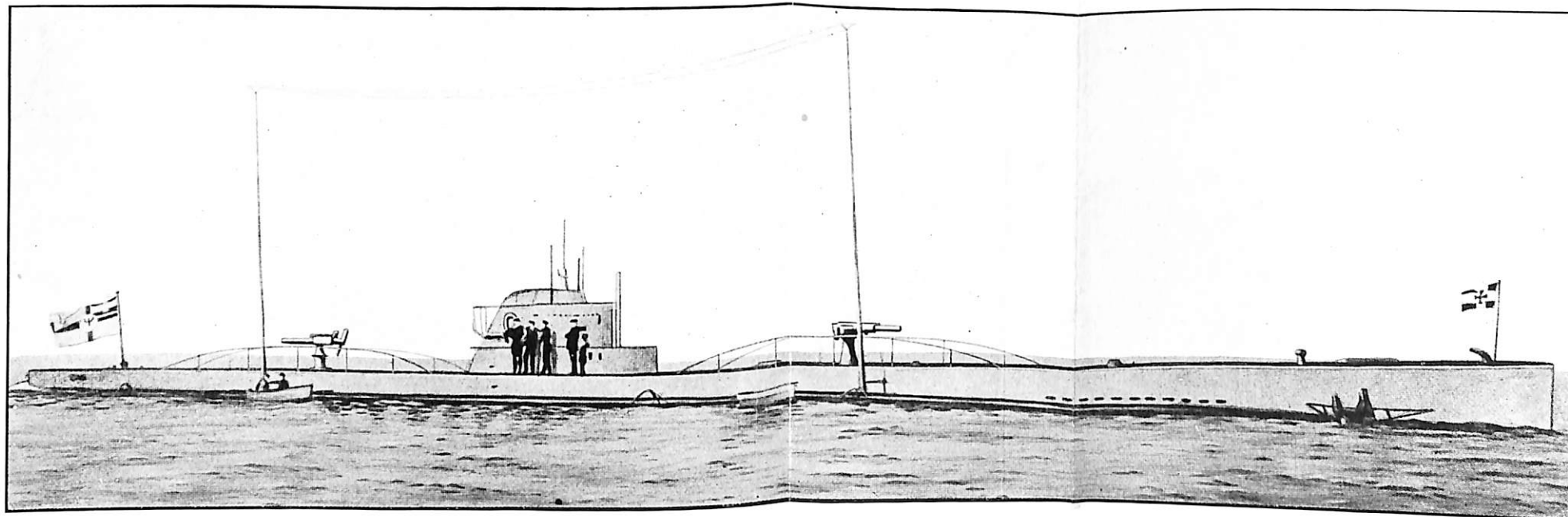
- 4 Oxygen bottles.
- Switch board.
- Centrifugal pump.
- Gyro master compass.
- Fan.
- Air compressor.
- Air purifiers.
- Auxiliary ballast pump.
- Trimming pump.
- Main ballast pumps.
- 2 Fresh water tanks (210 gals. each).
- 2 Fresh water compensating tanks (242 gals. each).
- Auxiliary ballast pump.
- Motor for raising masts.



Scale of Feet



SUBMARINE.



U. 53.
(U. 52-62).

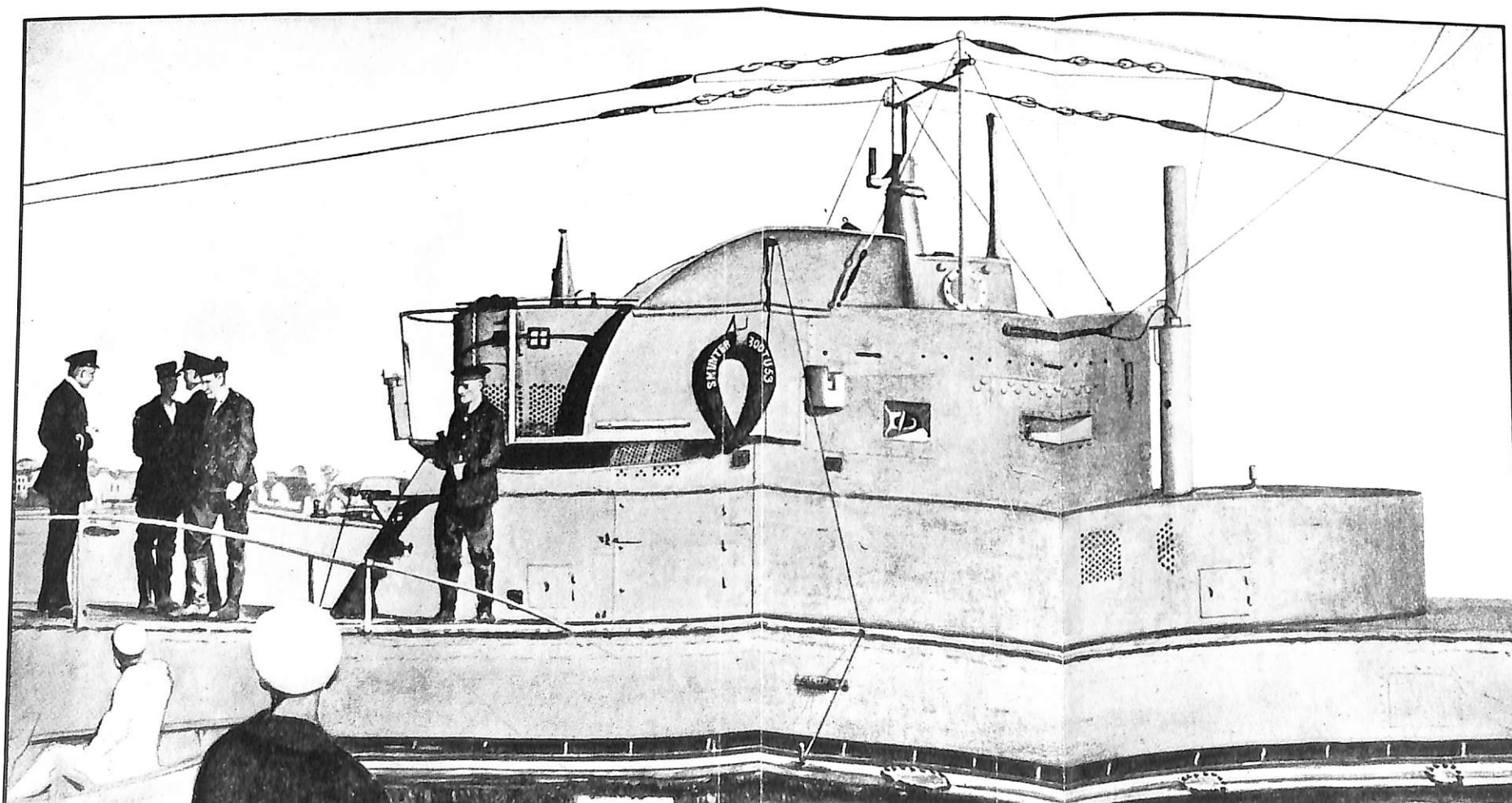
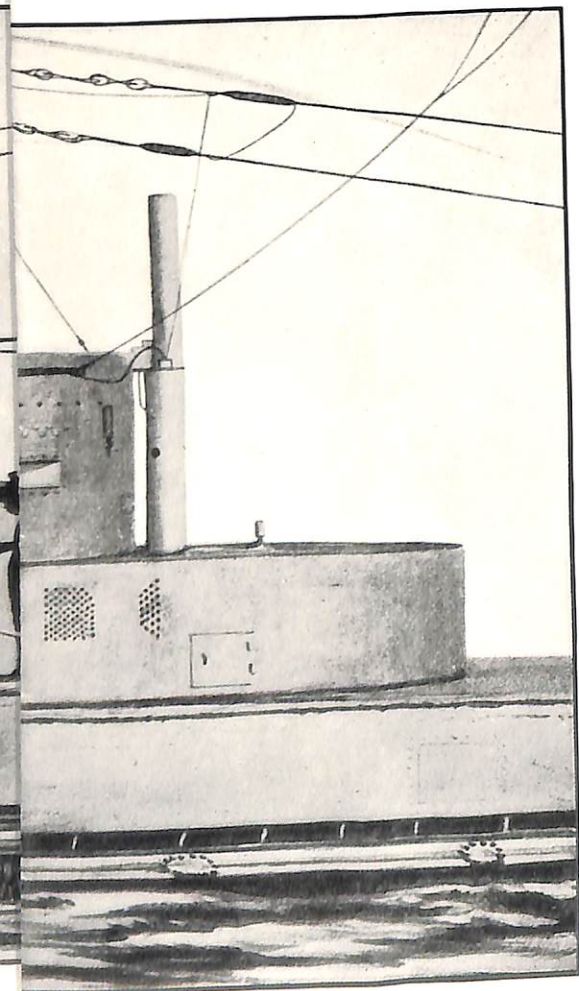
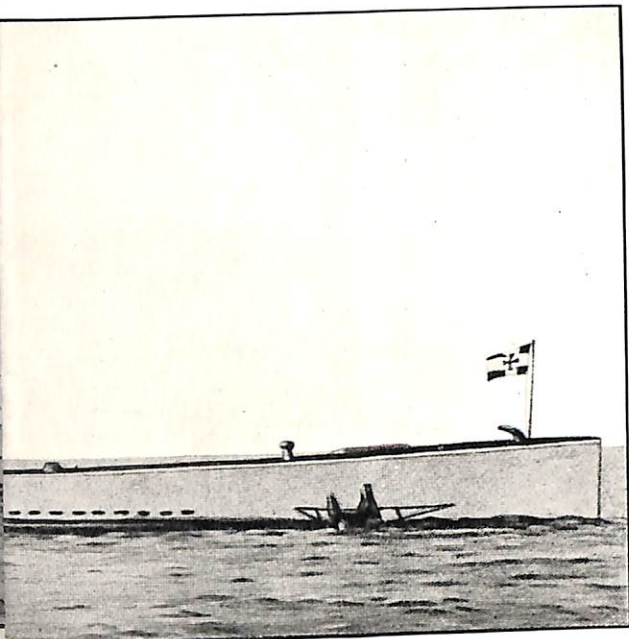


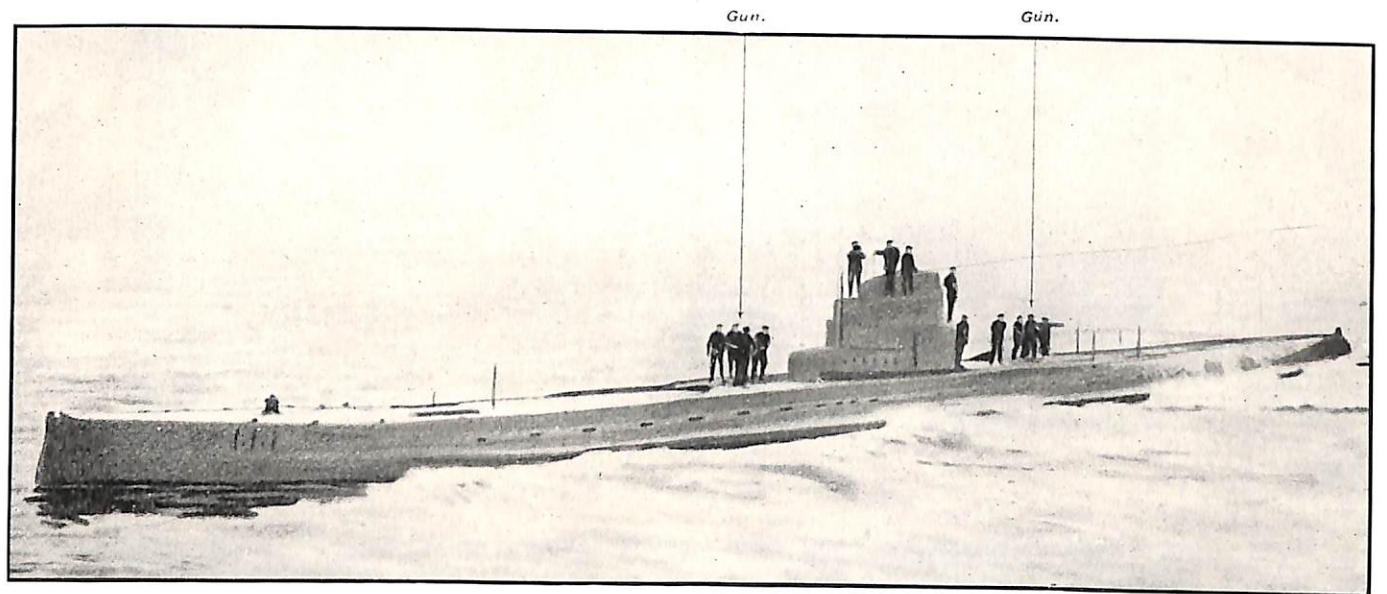
Plate 81.
C.B. 1182.
Part III.
March, 1917.



Ordnance Survey, March, 1917.

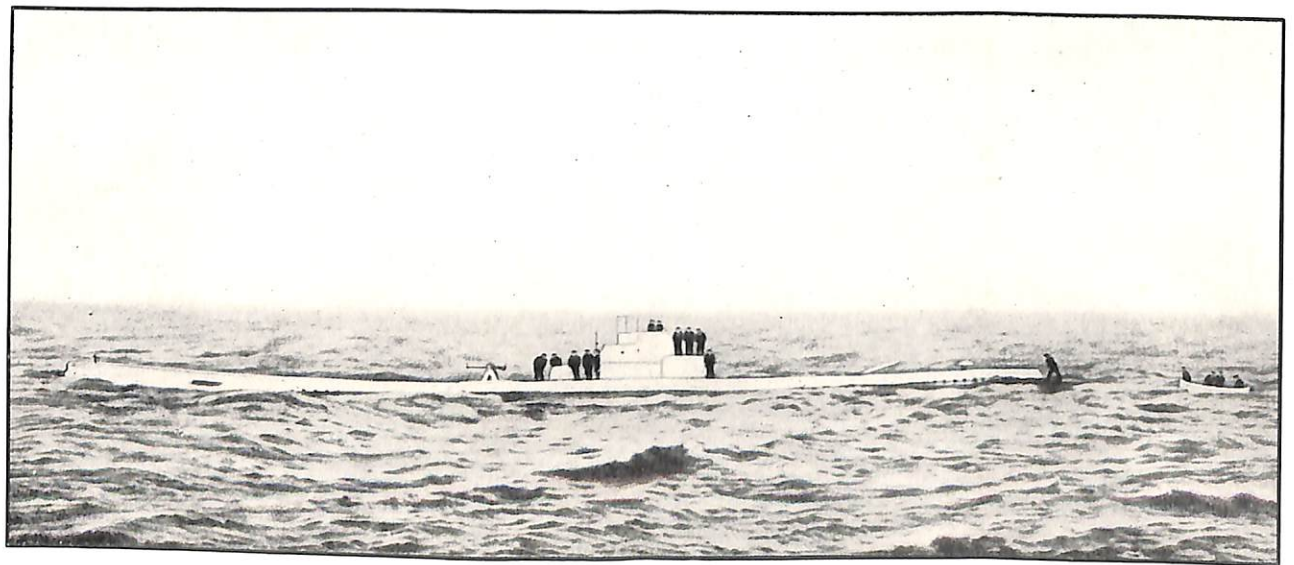
Plate 82.
C.B. 1182.
Part III.
March, 1917.

SUBMARINES.



U. 33-49.

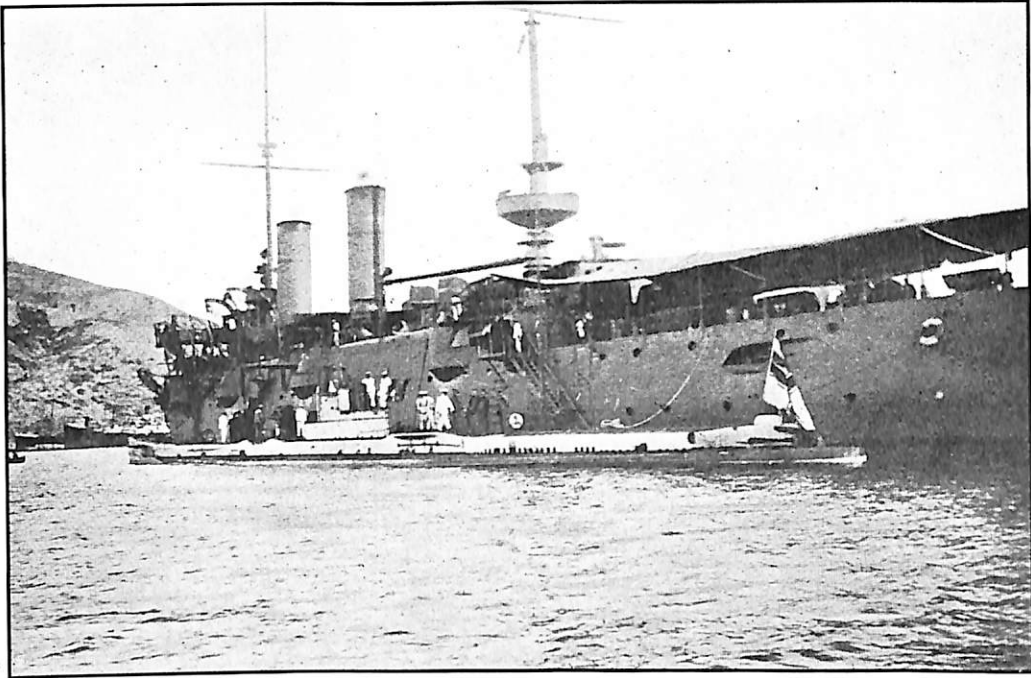
(Since date of Photograph, the 2-22 pr. guns have in several cases been replaced by 1-4'1 inch, mounted before Conning Tower)



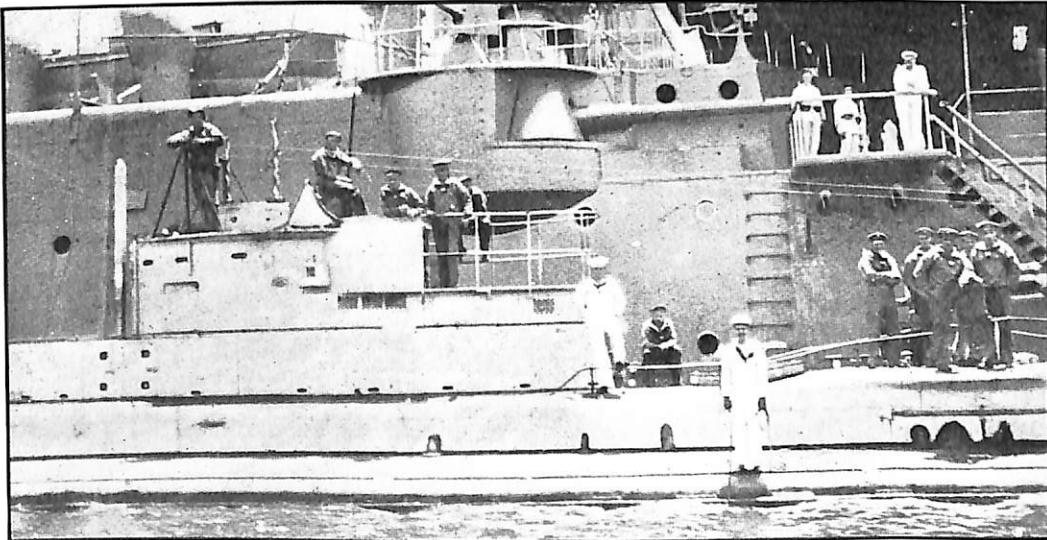
U. 33 - 39.

Photograph shows only one 22 pr. gun; armament is now either 2 - 22 pr. guns or 1 - 4'1 inch).

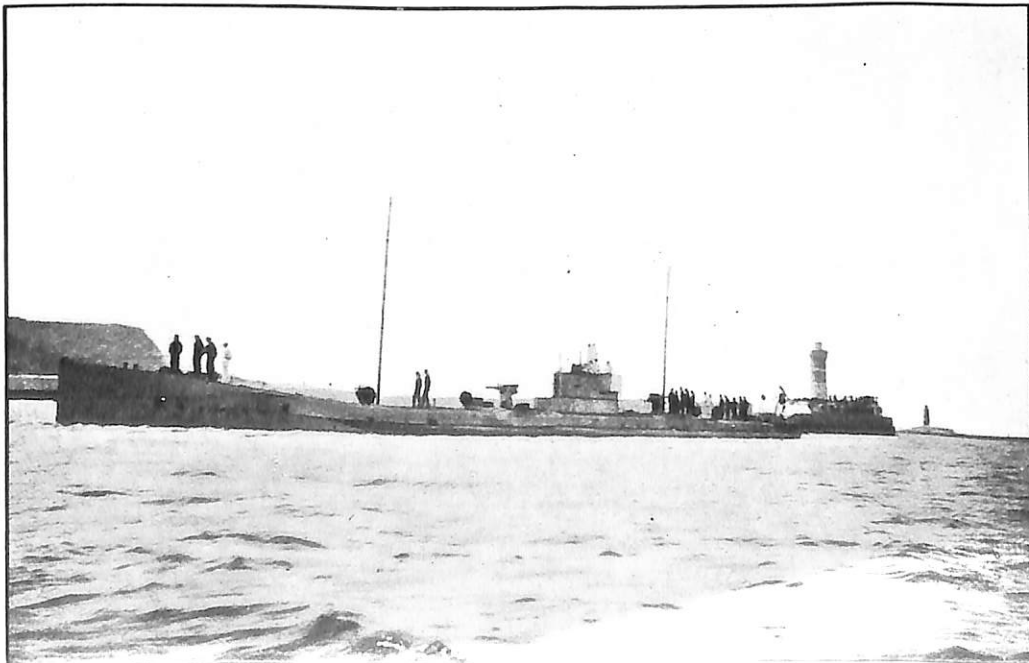
SUBMARINE.



U. 35.
(Alongside Spanish Cruiser).

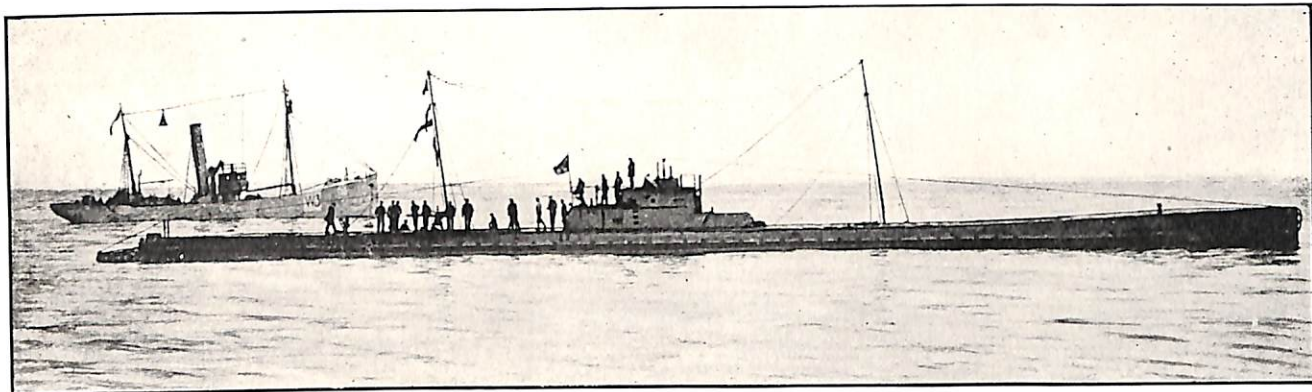


U. 35.
(Conning Tower).



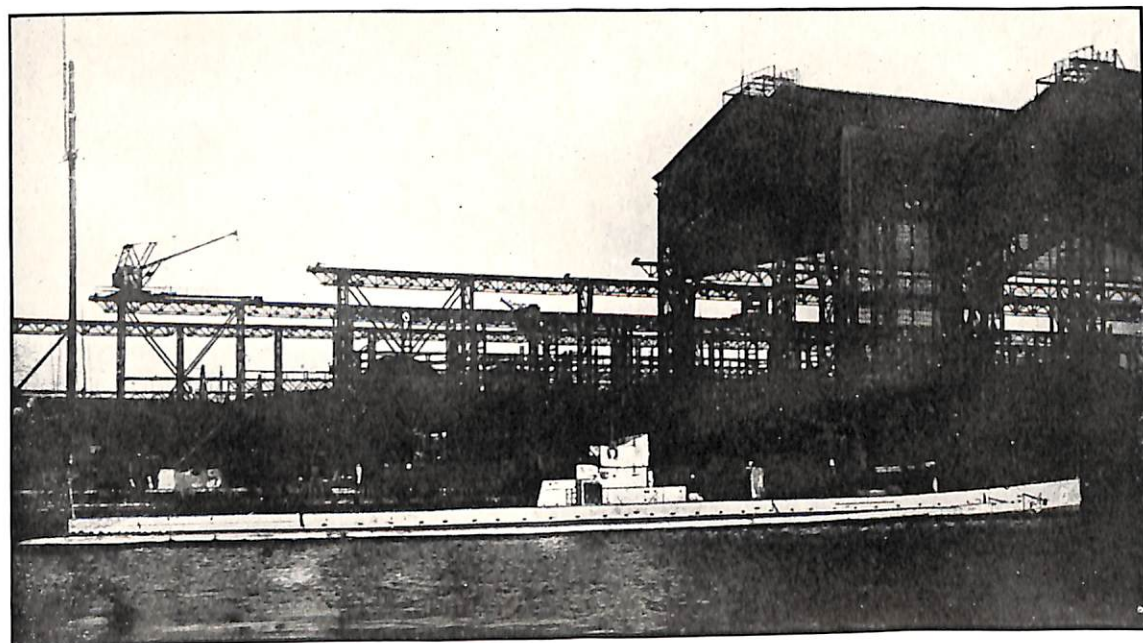
CLASSIFIED
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SUBMARINES.



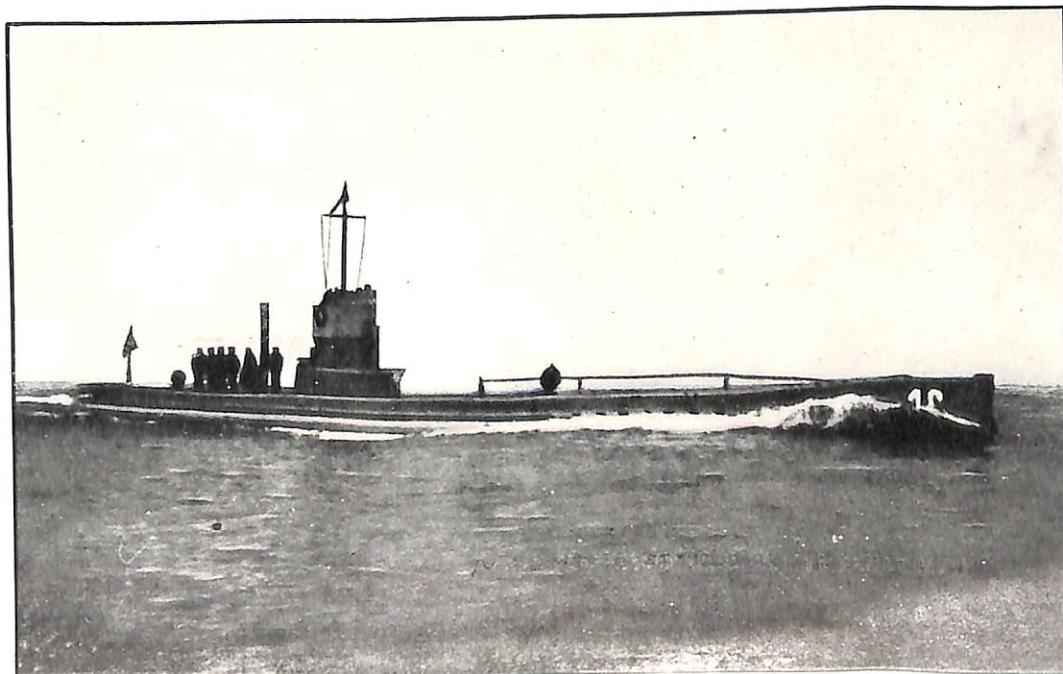
U. 28-32.

(Since date of Photograph, gun has been moved to fore side of Conning Tower).

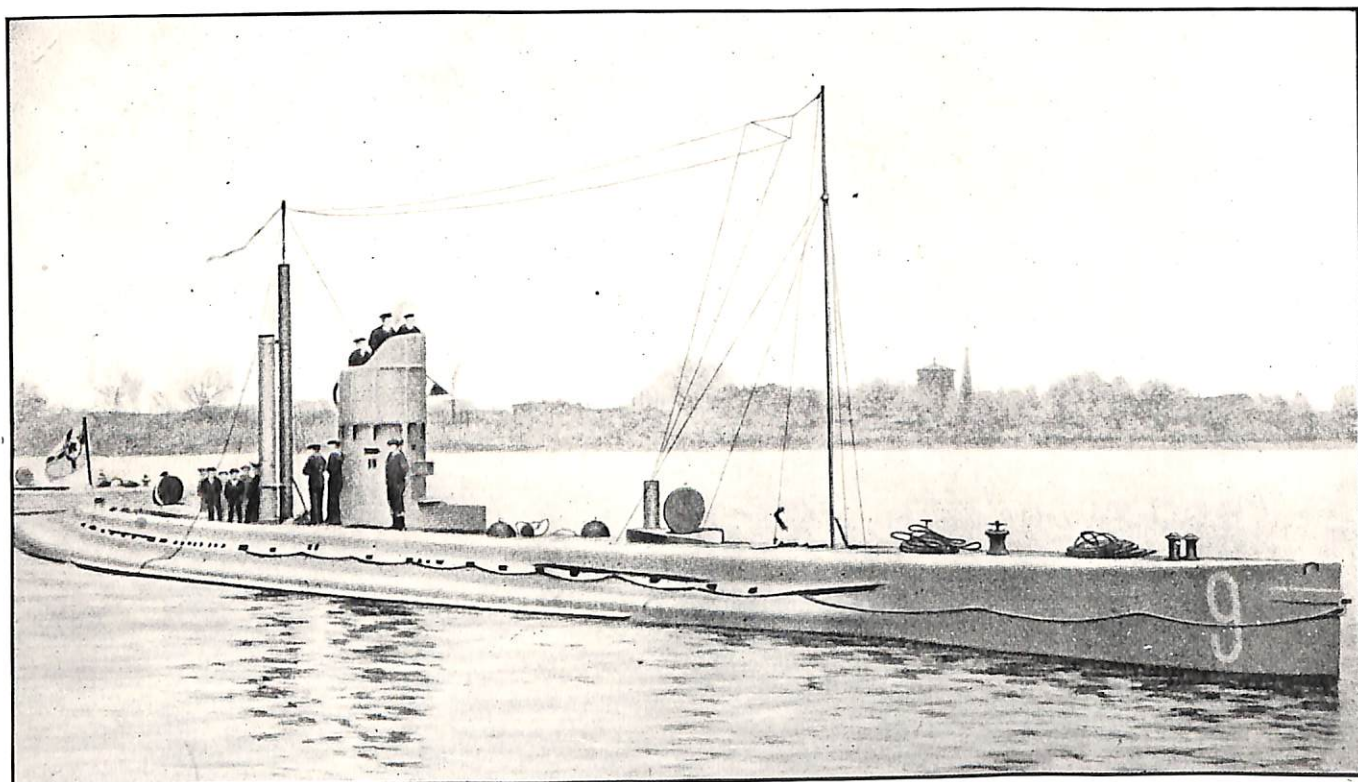


U. 21-25.

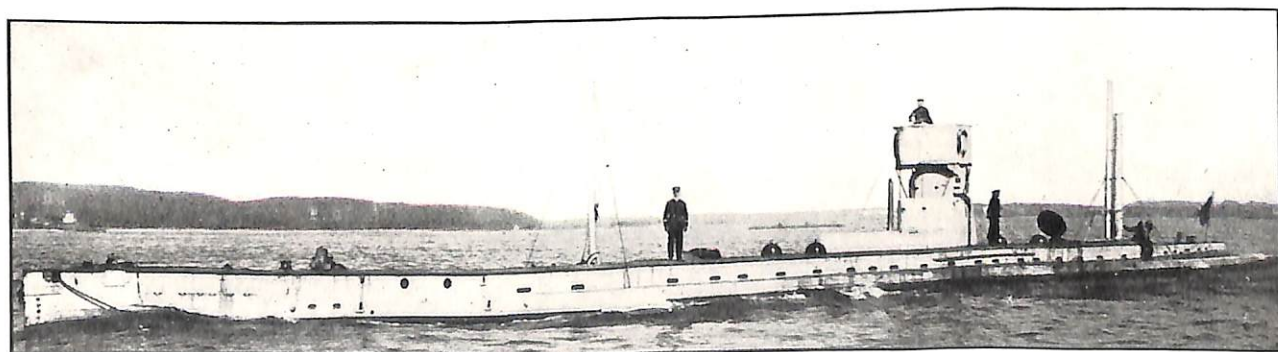
(Gun now mounted on fore side of Conning Tower).



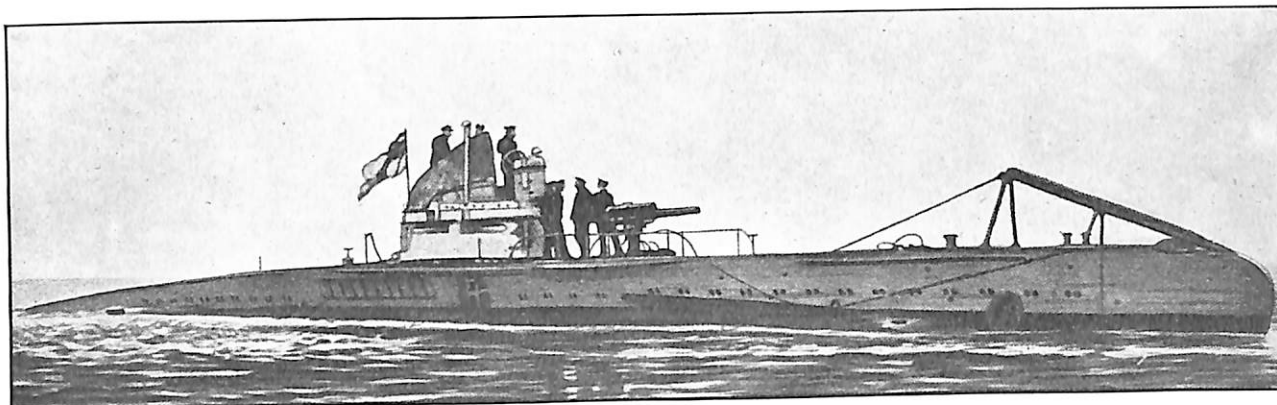
SUBMARINES.



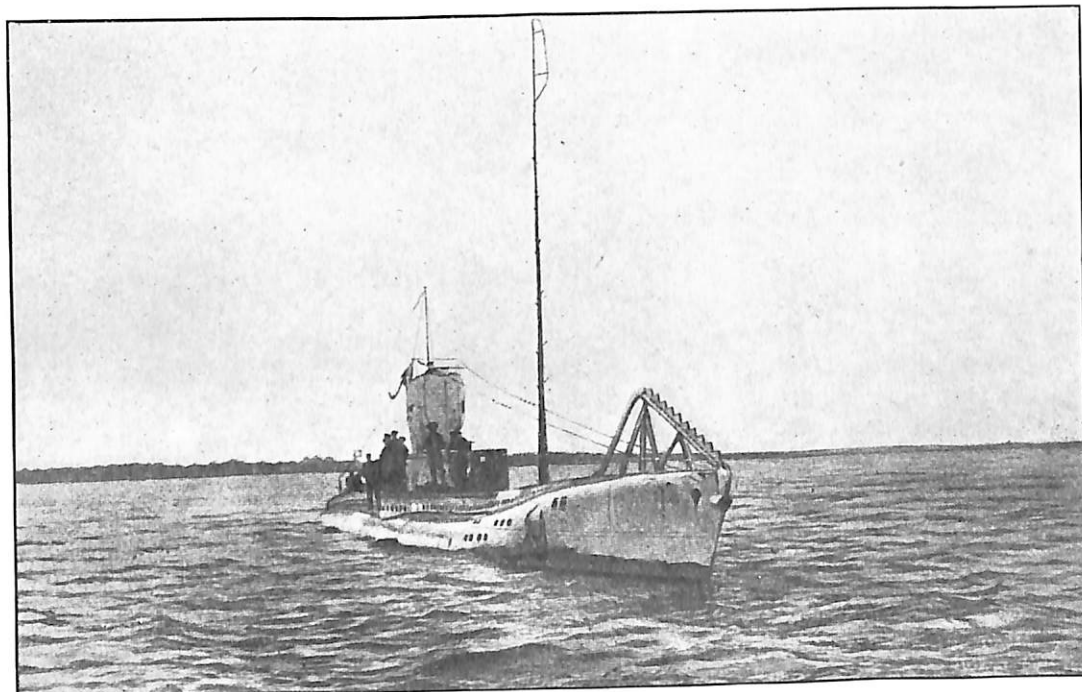
U. 9-12.



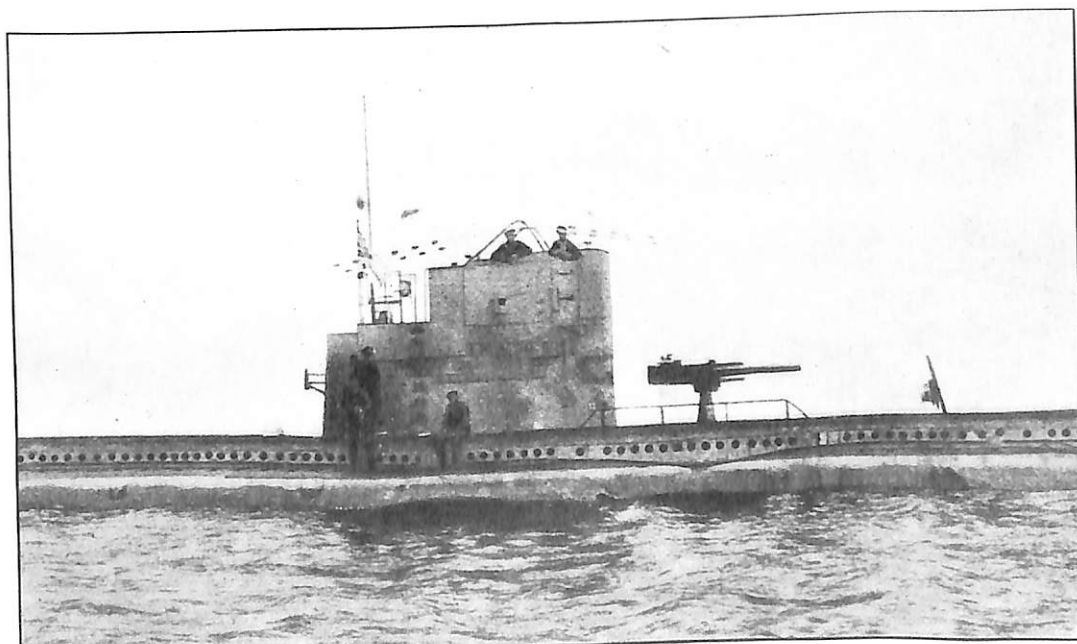
U. 3-4.



U. B. 18-47.



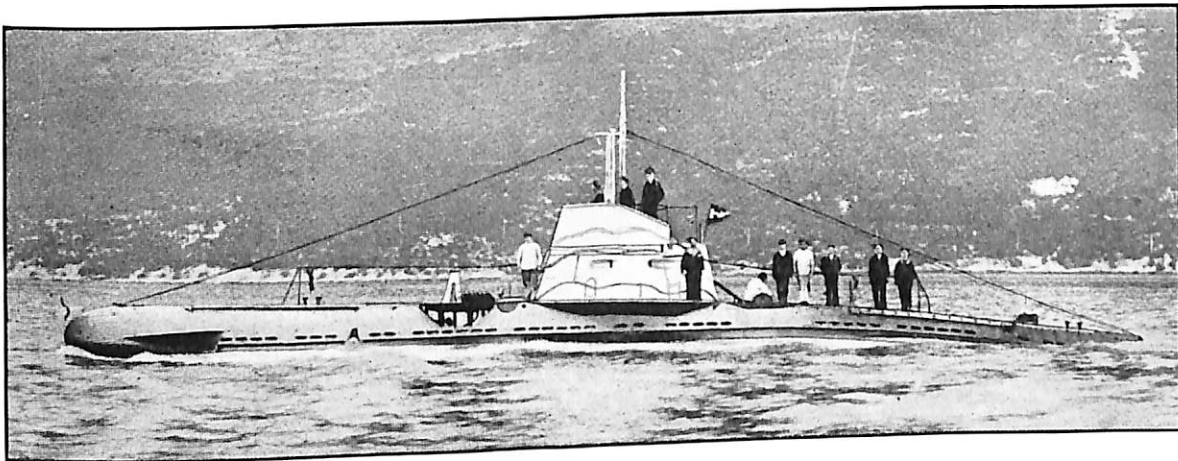
U. B. 48 Class.



CONNING TOWER.

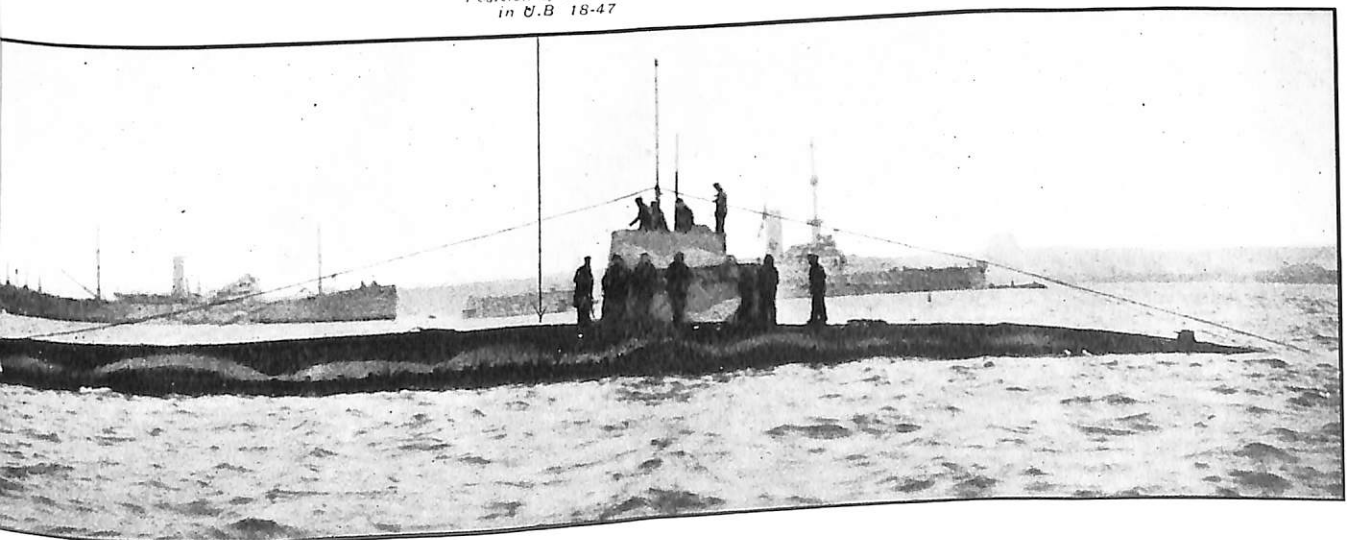
U. B. 49.

SUBMARINES.



U.B. 1-17.

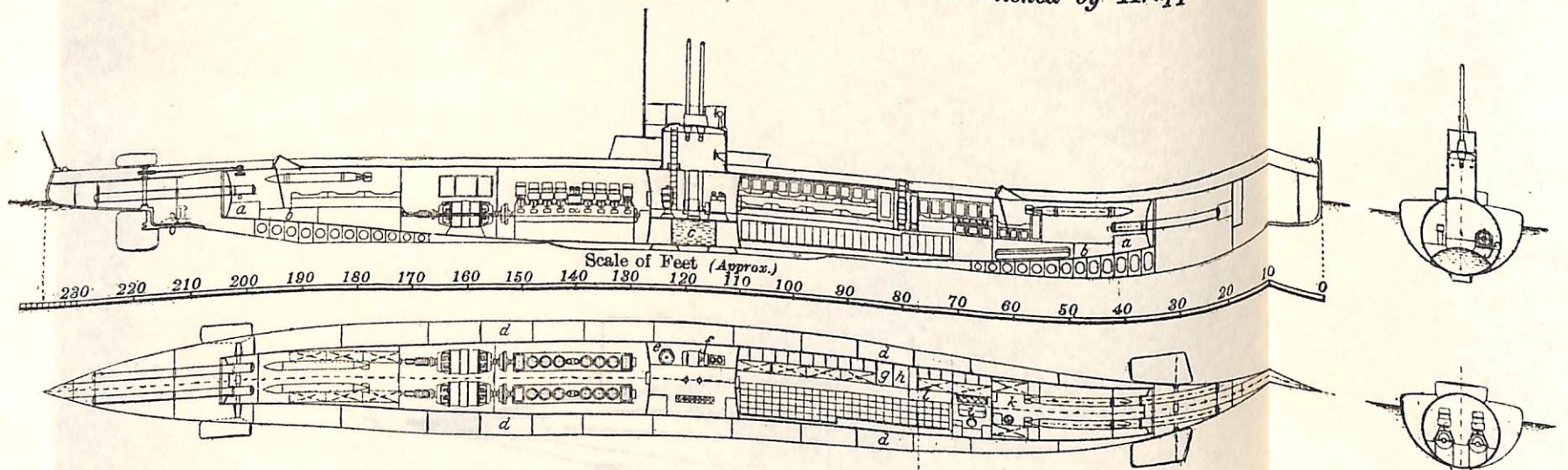
*Position of Gun
in U.B. 18-47*



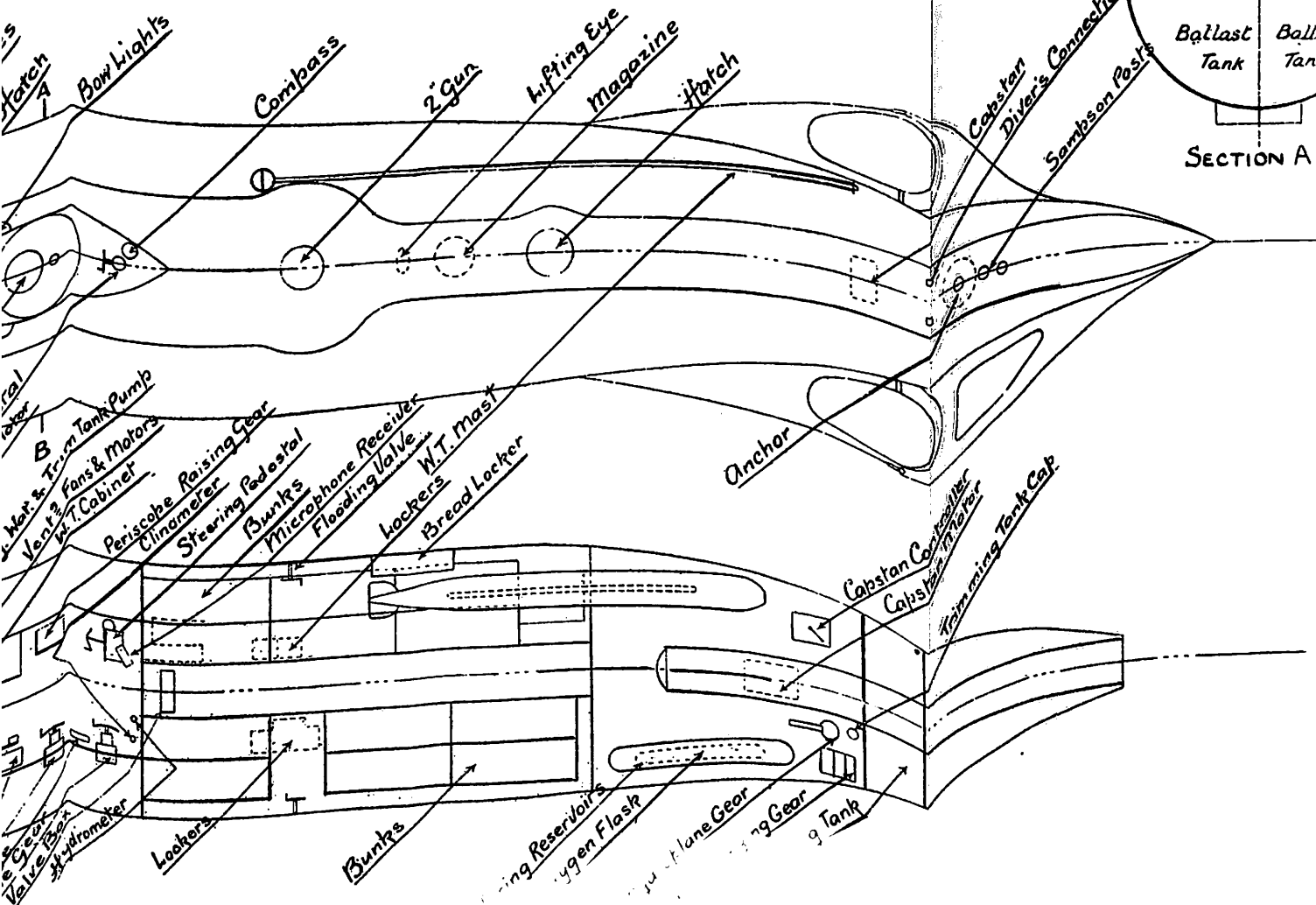
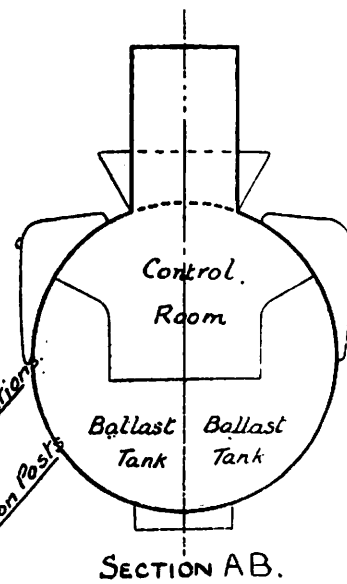
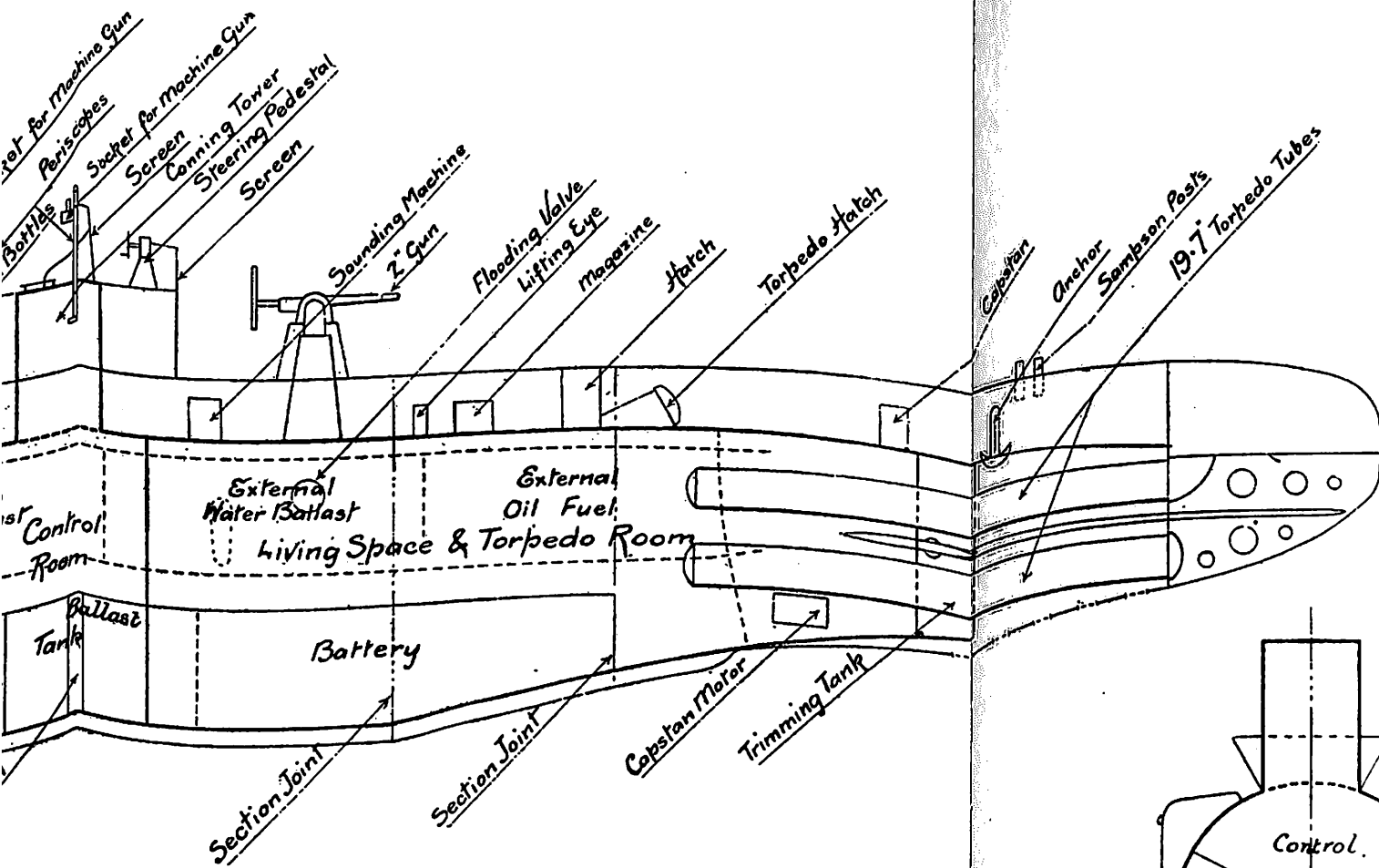
U.C. 1-15.

U.B. 18-47 very similar but 20 feet longer and have a 22-pr. gun before conning tower.
Note.—The painting in waves, as above, has only been adopted in a few of these boats.

Design for SUBMARINE, GERMANIA TYPE, Published by Krupp in 1912.

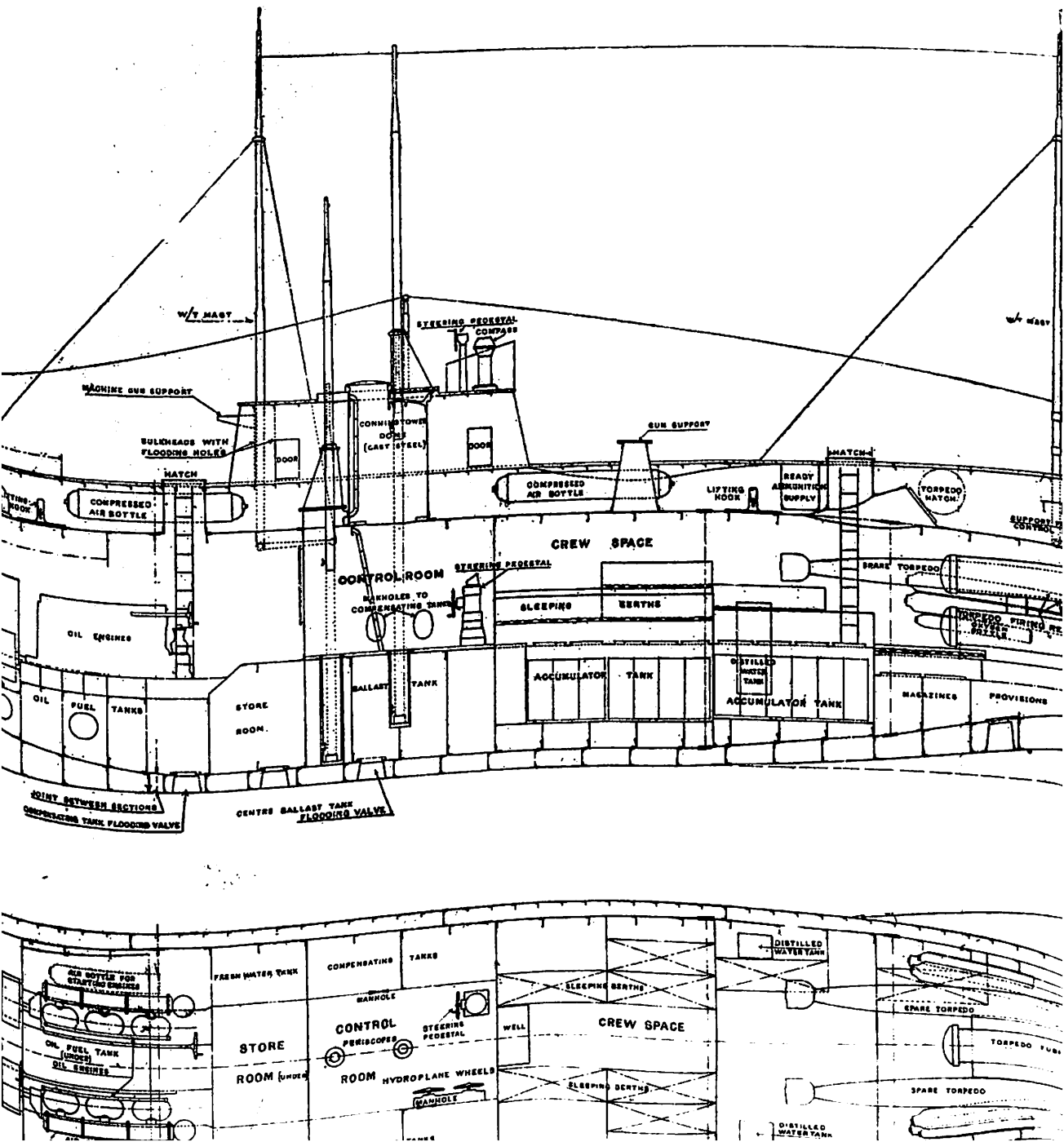


- | | | | |
|---|----------------------------|---|-----------------------------|
| a | Trimming tank. | g | Cupboard. |
| b | Torpedo Compensating tank. | h | W.C. |
| c | Compensating Tank. | i | Commanding Officer's cabin. |
| d | Oil Fuel. | k | Officers' quarters. |
| e | Main ballast pump. | l | Warrant Officers' quarters. |
| f | H.P. Compressor. | | |

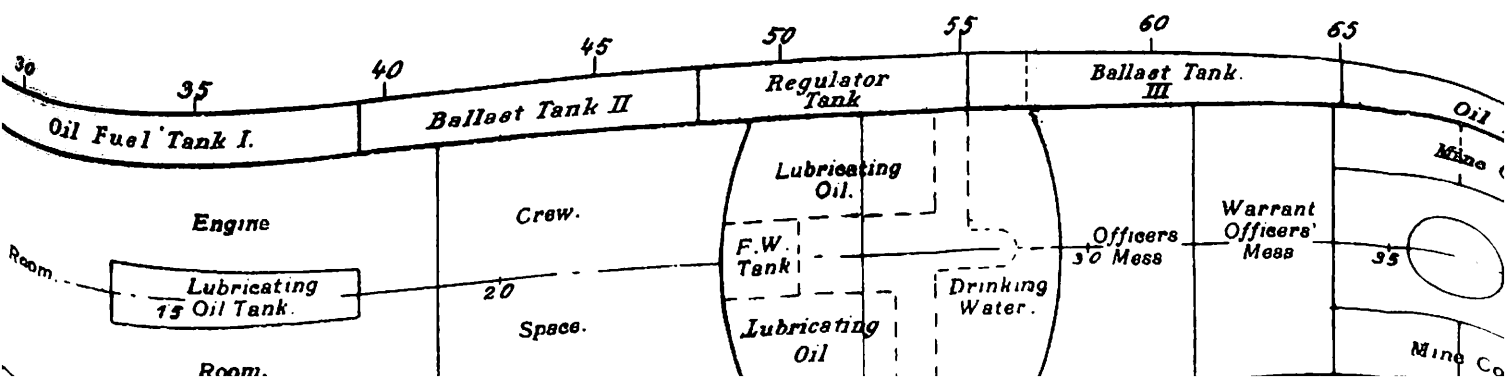
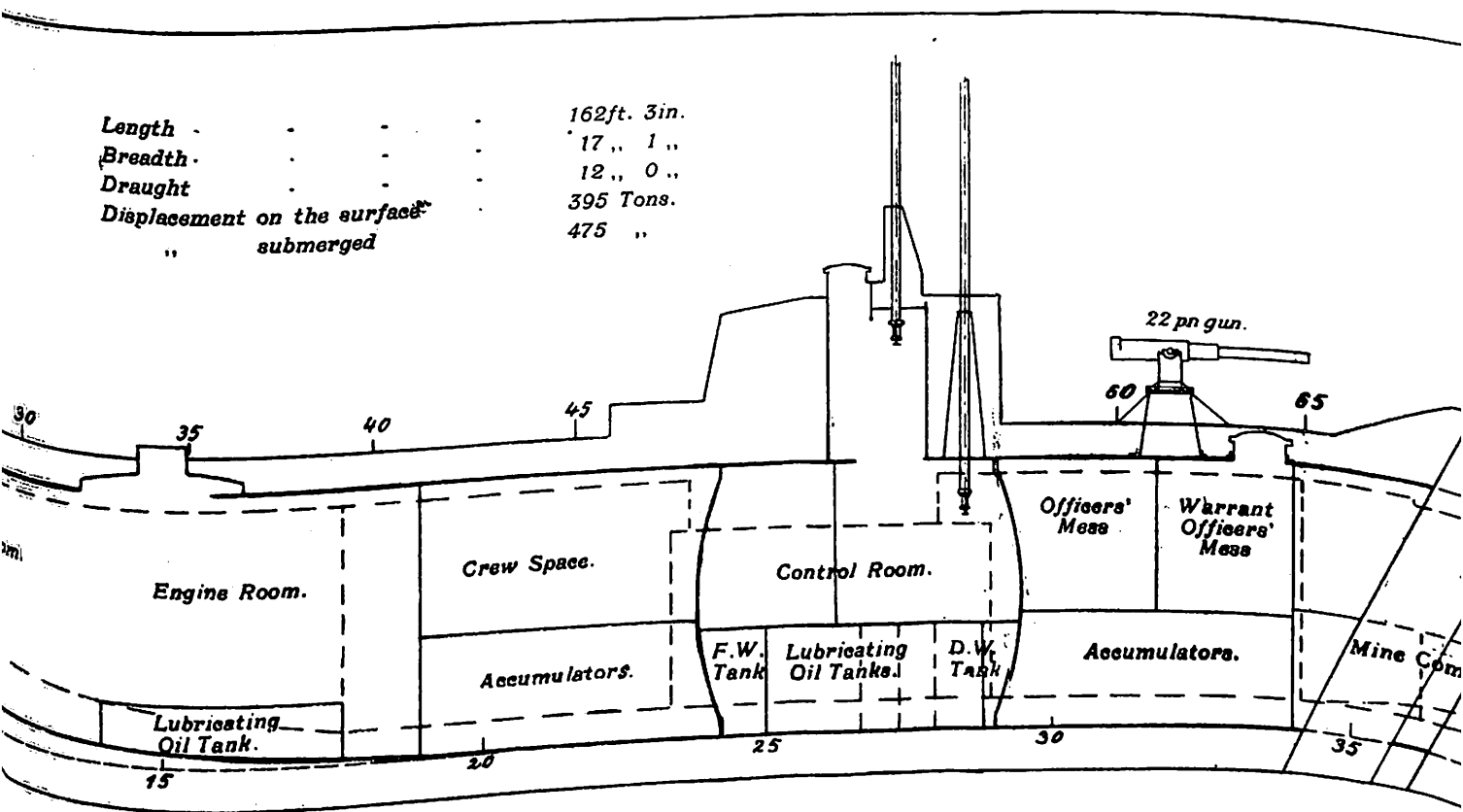


U.B.18-47 CLASS.

SCALE 1:100

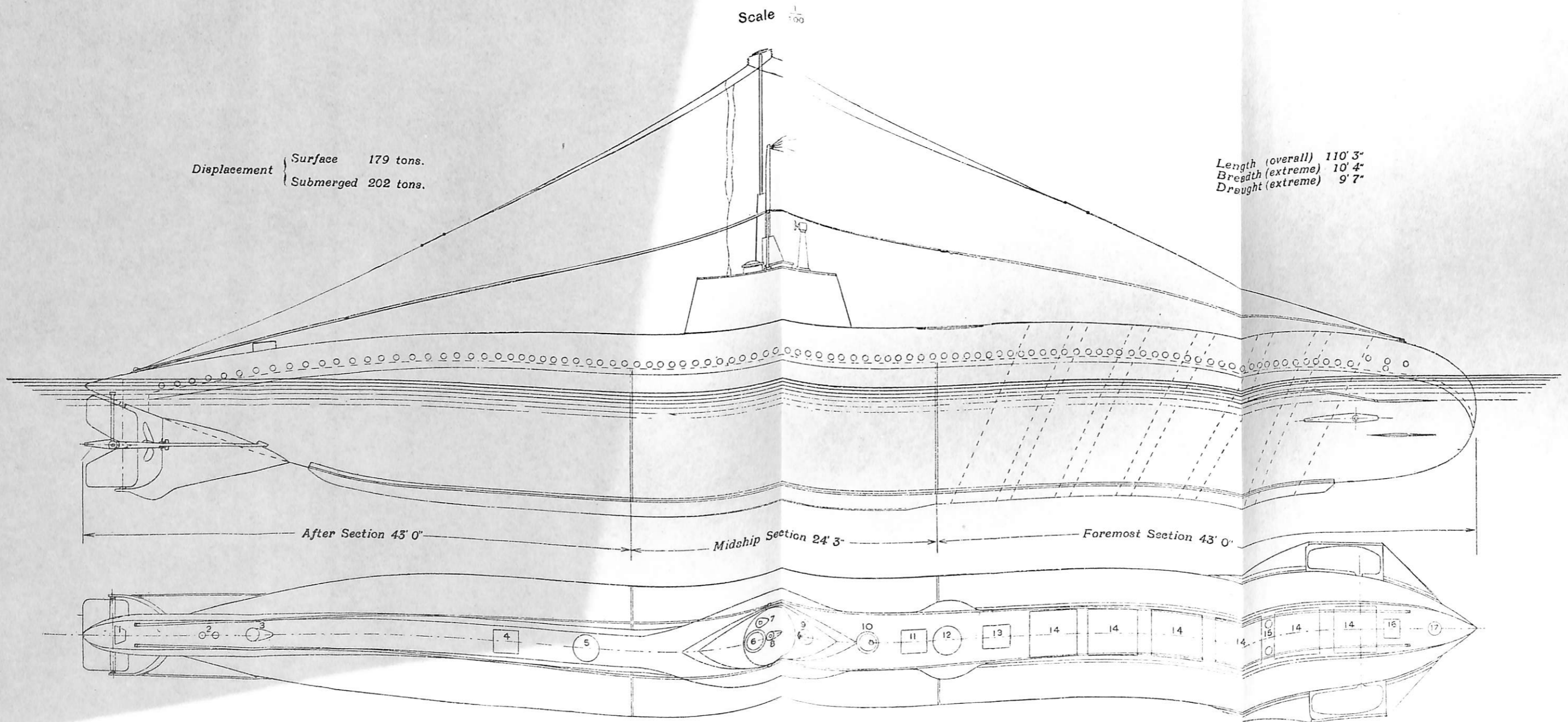


Length 162ft. 3in.
 Breadth 17 ,, 1 ,,
 Draught 12 ,, 0 ,,
 Displacement on the surface . . . 395 Tons.
 " submerged 475 "



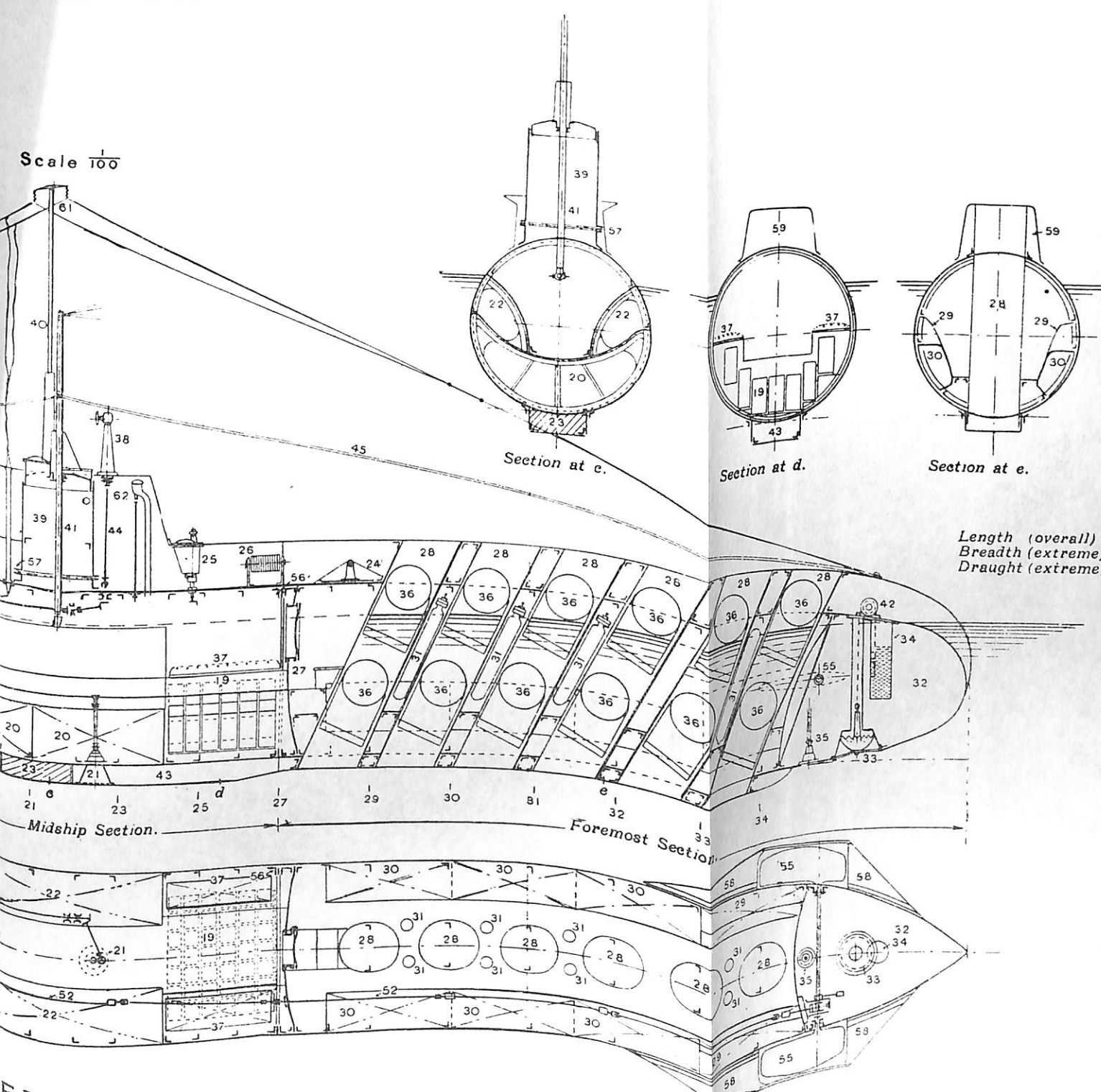
U.C. 11-15,
External view and Deck plan.

Plate 91.
C.B. 1182.
Part 111.
March, 1917.



REFERENCE.

- | | |
|---|--|
| 1. Manhole for inspection of rudder head. | 10. Telephone and light buoy. |
| 2. Portable Bitts | 11. Manhole over sounding gear. |
| 3. Stern Light. | 12. Machine Gun Stand. |
| 4. Manhole over after lifting shackle. | 13. Manhole over foremost lifting shackle. |
| 5. Hatch leading to Central Compt | 14. Gmtings over Mine Tubes |
| 6. Conning Tower hatch. | 15. Portable Bitts |
| 7. W. T. Mast | 16. Manhole over Capstan |
| 8. Periscope | 17. Air exhaust from foremost compartment. |
| 9. Stern 2 Wheel fitted to unship | |



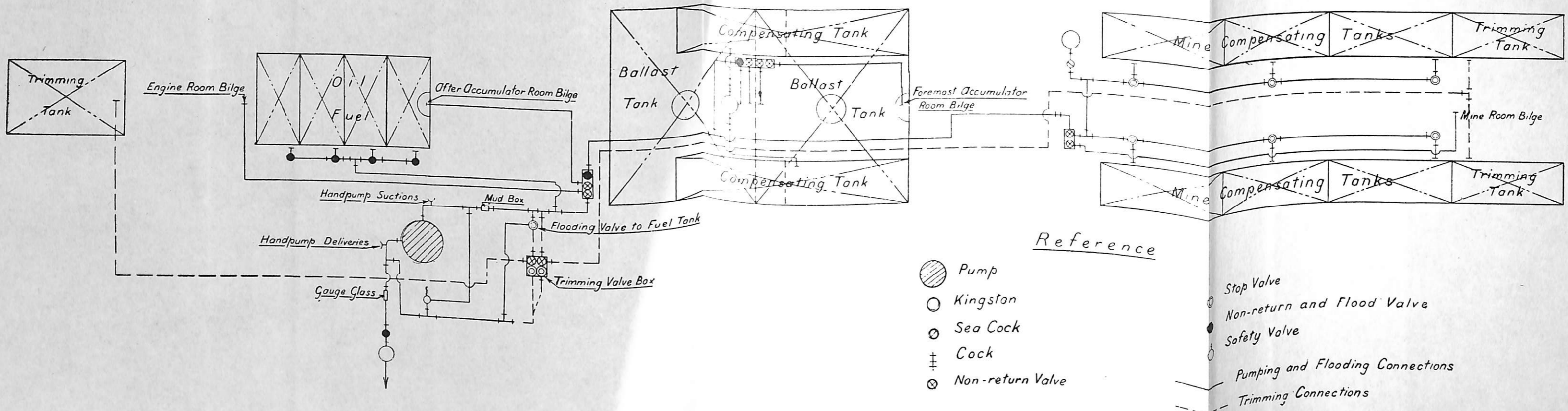
Length (overall) 110' 3"
 Breadth (extreme) 10' 4"
 Draught (extreme) 9' 7"

REFERENCE.

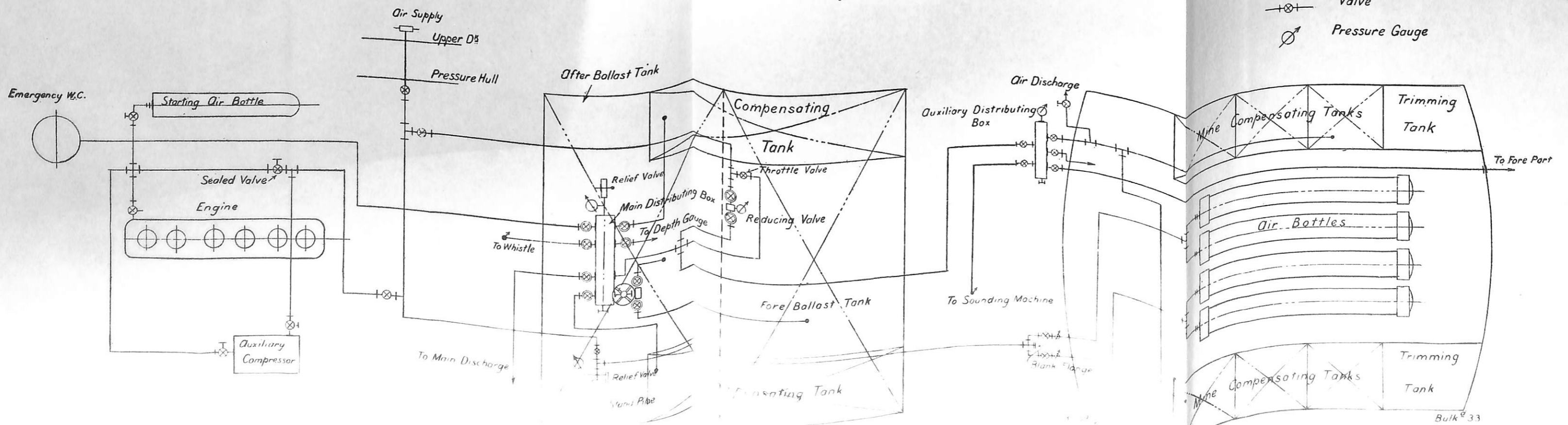
- 33. Mushroom-head Anchor, 3 cwt.
- 34. Cable Locker, 55 fms., '63".
- 35. Kingston.
- 36. Mines, 12 in number, charge 264lbs. T.N.T., negative buoyancy 660 lbs.
- 37. Bunks, 6 in number.
- 38. Steering Wheel, fitted to unship.
- 39. Conning Tower, diameter 4' 3", open to pressure hull.
- 40. Telescopic Mast, top 26 ft. above water-line.
- 41. Periscope, diameter 3' 5" - 5' 9" raised by electric motor of 4 1/2 H.P. which also works capstan.
- 42. Capstan.
- 43. Ballast Keel, 18 3/4 tons.
- 44. Fairwater surrounding Conning Tower.
- 45. Jumping Wires, 12'.
- 46. After Hatchway.

- 47. Hand Wheel for Vertical Rudder.
- 48. Gearing of Vertical Rudder.
- 49. Hand Wheel for Diving Rudder.
- 50. Hand Wheel for Foremost Hydroplanes.
- 51. Gearing of Diving Rudder.
- 52. Gearing of Foremost Hydroplanes.
- 53. Rudder, area 25 sq. ft.
- 54. Hydroplanes, area 19'4 sq. ft.
- 55. Flanges, fitted with bolts and rubber packing, area 11'8 sq. ft. each.
- 56. Flanges for Conning Tower.
- 57. Guard.
- 58. Fairwater (open to sea).
- 59. Oil Tanks, 189 gallons.
- 60. Wires, length 50 ft.
- 61. Wires from tanks.

(a) Pumping, Flooding and Trimming Arrangements.

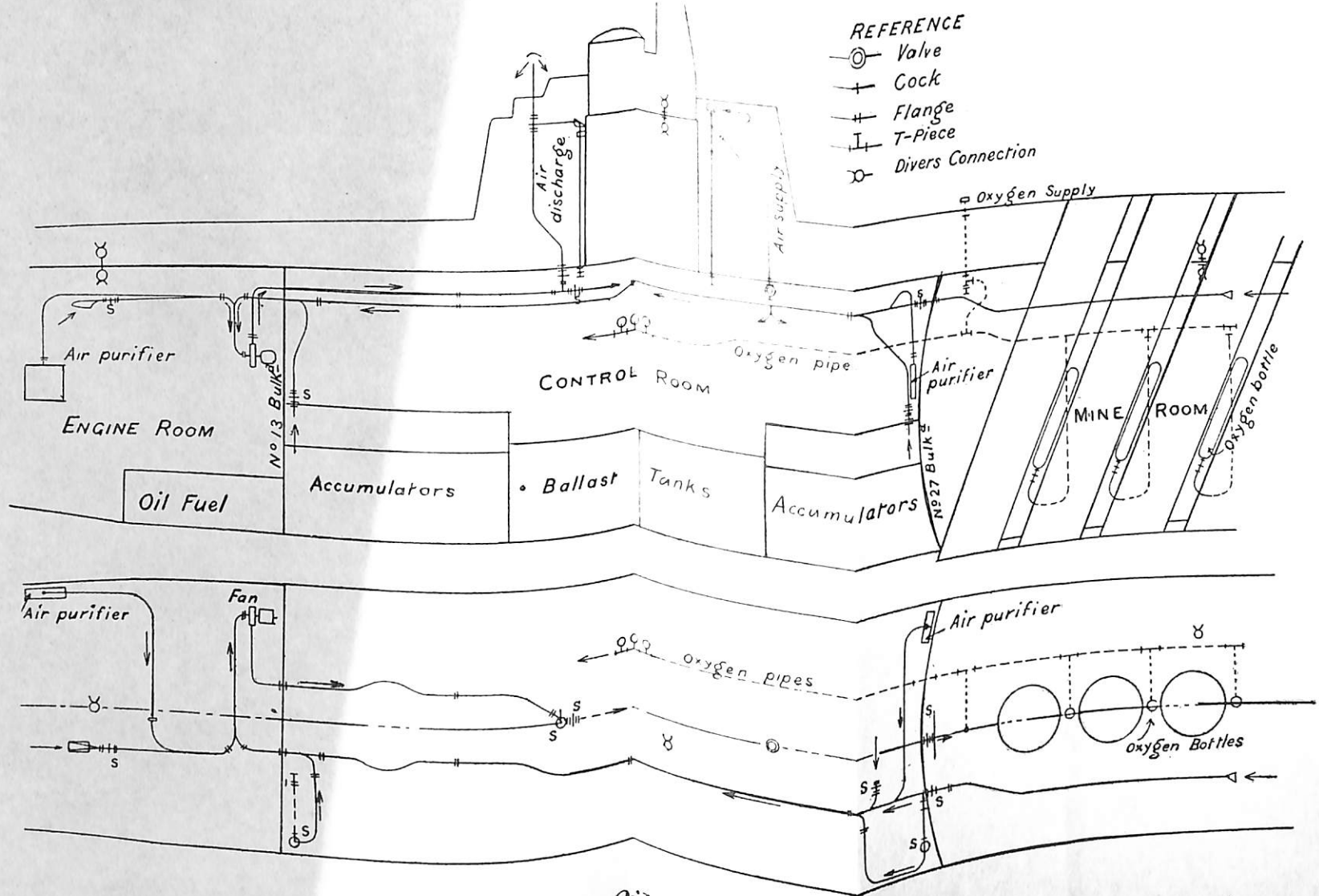


(b) Compressed Air System.



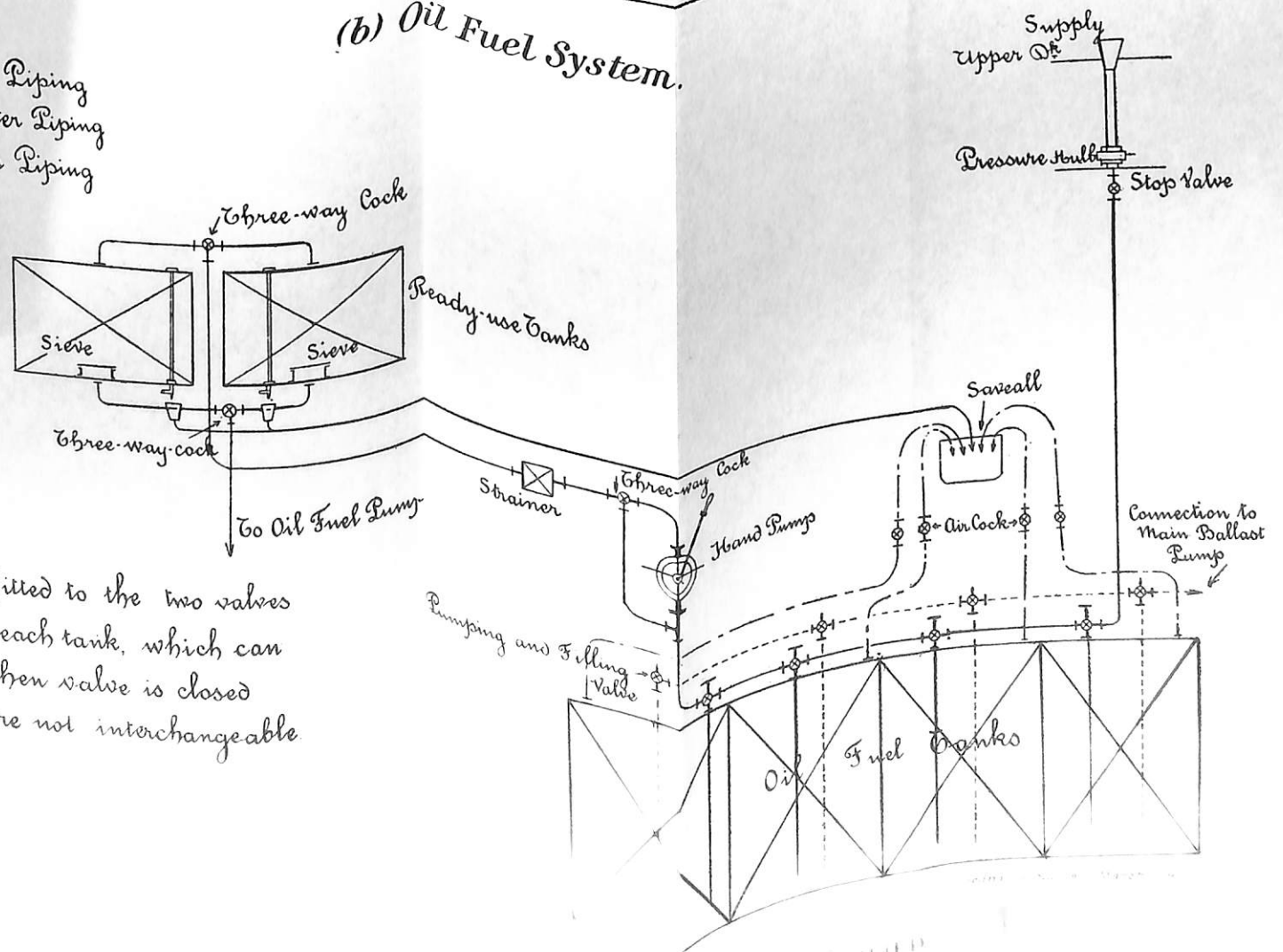
Bulk # 33

(a) Ventilation System, Air Purifying and Oxygen Supply Arrangements, and Divers Connections.



(b) Oil Fuel System.

— Oil Piping
- - - Water Piping
- · - Air Piping



A hand wheel is fitted to the two valves (oil fuel and water) of each tank, which can only be removed when valve is closed. The four wheels are not interchangeable.

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