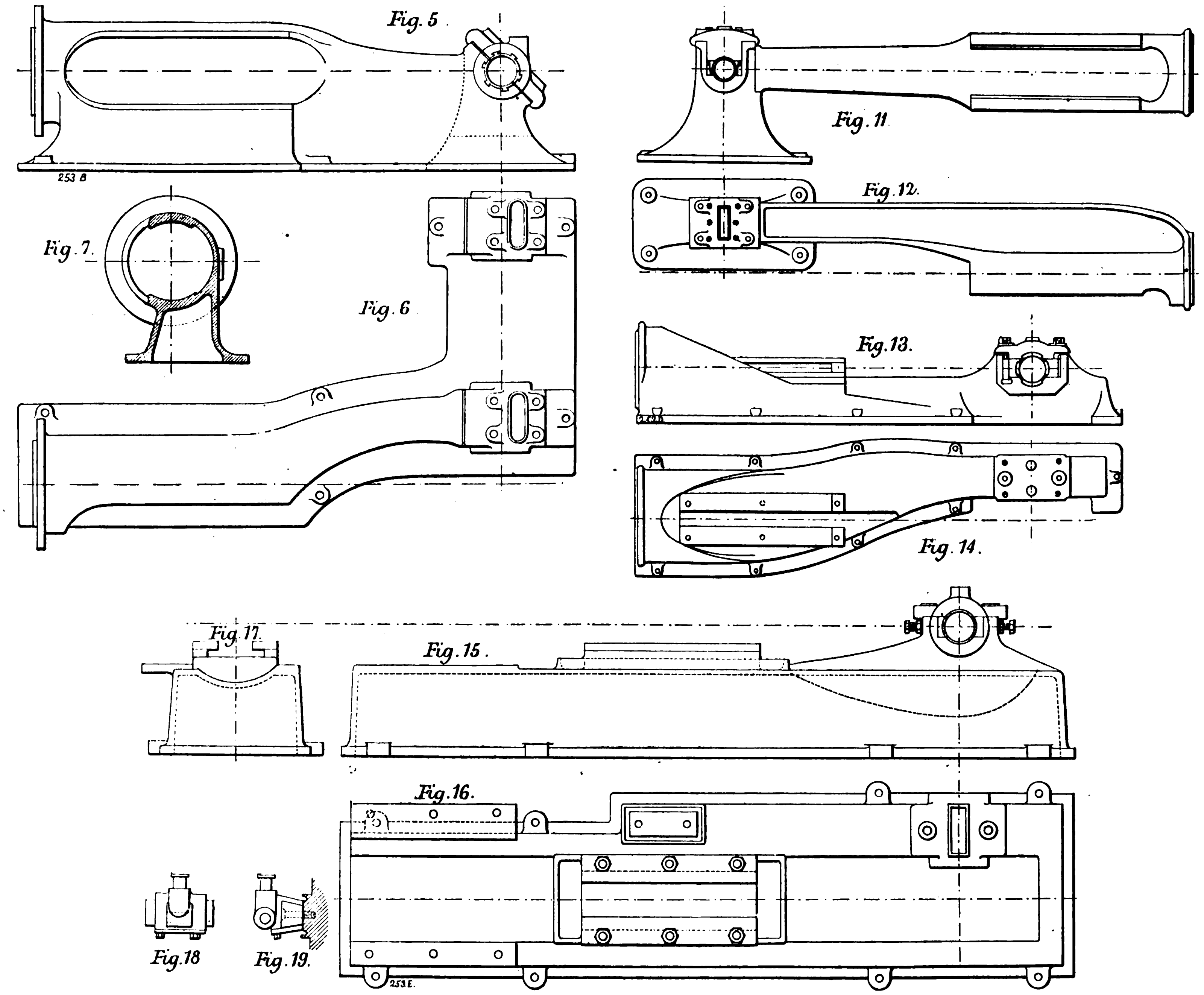
in depth of rivers and streams, so that auxiliary pumping becomes expensive. The Ohio River at Cincinnati has a depth of about 4 ft. at low water and over 70 ft. at its highest stage. This is an extreme case, but other rivers and streams vary over 25 ft. or 30 ft.

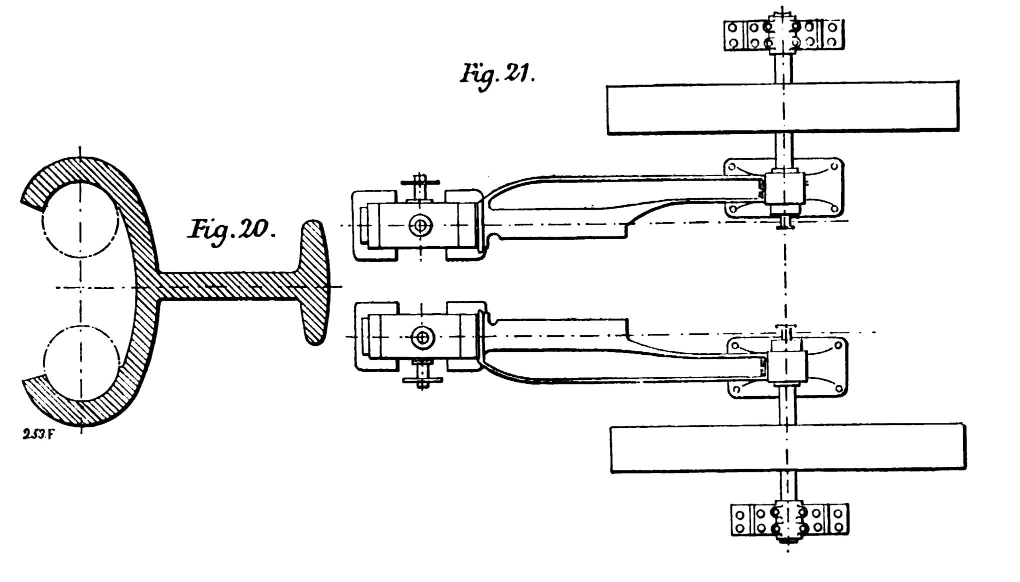


Further, the first cost of machinery is a matter of importance where the rate of interest is high, and where manufacturing and business establishments grow rapidly. It is not an uncommon experience to replace an engine by a larger one within three years. In such a case the simplest and least expensive engine, as to price, is the most economical; therefore, any system of pumps, pipes, &c., for a condenser are not thought of unless the location makes the advantage obvious at once.

One example more—American cities contain a large number of small industries requiring power varying from 5 to 150 horse-power. Engines are placed in basements and cellars, and small ones on the floors of buildings to furnish this supply of energy. On a clear cold morning one can see, looking over the roofs of these towns, little clouds of white vapour escaping from numberless exhaust pipes. Engines so situated cannot obtain condensing water at any reasonable rate, while the advantages of ndependence and subdivision of power are evident.

I. Details.

In describing the details no remarkably new and novel forms will be considered, but only those that can be found in general practice; the object of these articles being to reflect that which is permanent rather than to expatiate upon recent experiments in construction.



The Bedplate.—Engines are either self-contained or have one bearing independent of the bedplate.

Self-contained Bedplates.—The self-contained engine has a "double-throw" or a "side-hitch" crank. Figs. 3 to 7 show the two forms of bedplate as used with each respectively. Small engines with "double-throw" cranks are the most numerous, although the other is gaining in popularity, as the cost of its crank, shaft, and connecting-rod is much less, and its parts are more accessible; its disadvantage consists in the fact that each engine must be either right or left hand, therefore the design is not so adaptable to varying location as the other, and more stock has to be carried to satisfy the same demand. Many slide-valve engines, and most high-speed automatic cut-off engines, are self-contained. With the latter, this construction secures accurate and permanent alignment of shaft with the cylinder and guides, a necessary feature for successfully running at a high number of revolutions. In

MODERN FRENCH ARTILLERY.

(*For Description, see Page* 4.)

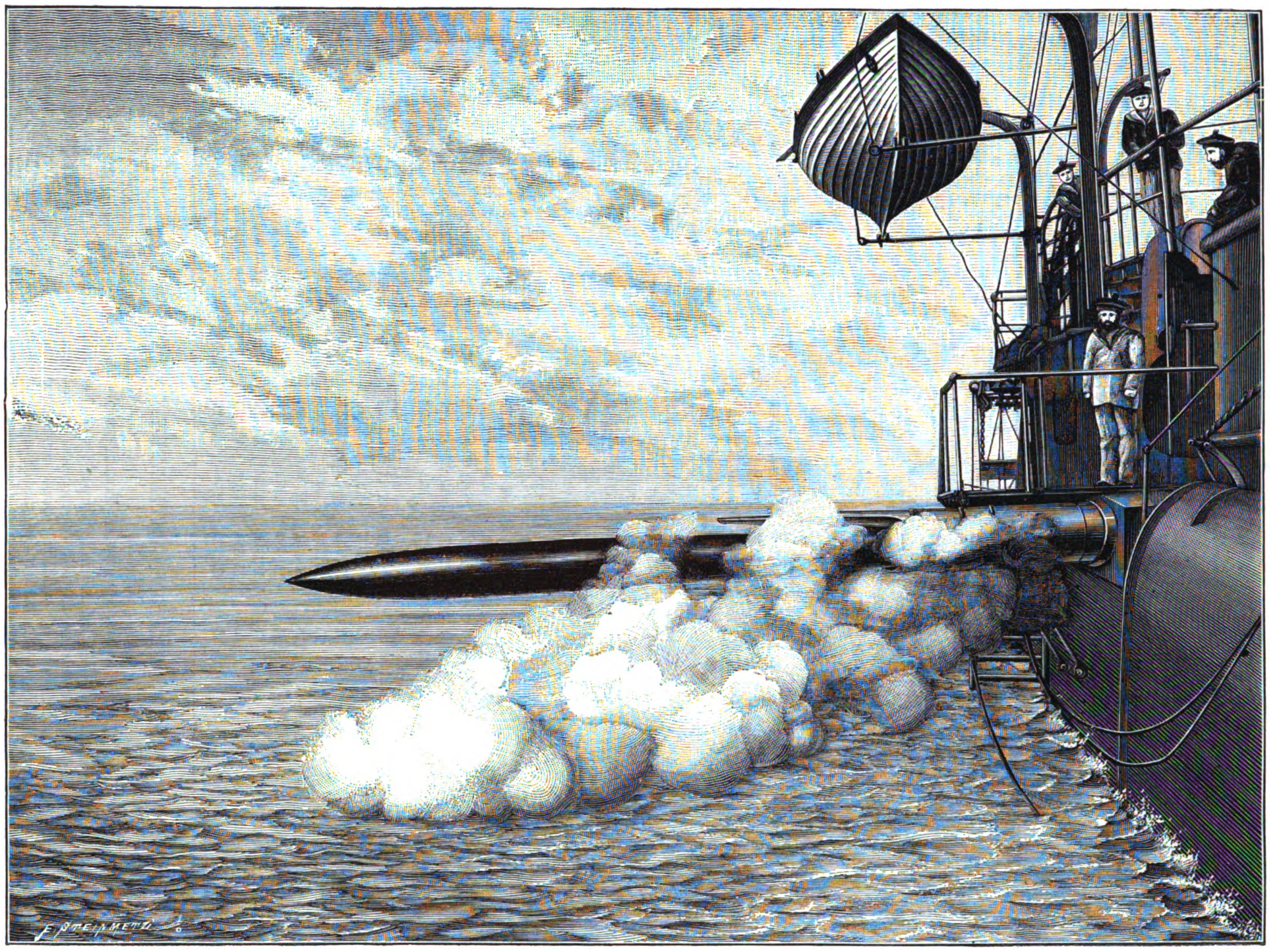


FIG. 511. FIRING A TORPEDO FROM THE FRENCH GUNBOAT "CONDOR."

these engines both bearings have to be of the same character, so that wear can be taken up alike in both.

The locomotive guide is the prevailing form of crosshead guide used with the double-throw crank type of engine. It is accessible and adjustable for wear, the bedplate casting can be made without large cores, and the quality of metal in the slides can be good. There are a number of bored guides in use, but their advantage on small engines is more apparent than real. The crosshead becomes more expensive, the casting is not so simple. Let us consider for a moment the machining of two bedplates having bored and locomotive guides respectively. The first has to have bearings and "spots" planed; the guides are bored and the end of frame for the cylinder "fit" faced off and bored. The second has bearings and "spots" planed, and in addition the seat for the guide bars is planed; its end is faced and bored. Both have to be placed in the planer and lathe, one has more "lathing" and less planing, and the other *vice versâ*. The extra planing of locomotive guides is nearly offset by the cheaper crosshead that can be used, and the fact that much of the fitting can be done at the bench instead of on the erecting floor.

The cylinders of self-contained engines of recent design are bolted to the ends of the bedplate; among some older patterns there remain a few box beds with cylinders bolted on by flanges.

Another attachment to the bedplate is the valve stem guide or rocker arm. Main bearings in America are so long that a direct connection between eccentric and valve stem is impossible; an offset has to be made in the connection or else the steam chest will be too deep. This offset is obtained by means of a "side-hitch" guide or a rocker arm. Both of these are usually secured to the bedplate by being bolted to a "spot;" sometimes the guide is cast to the bedplate, as shown in Figs. 3 and 4. The rocker in some instances vibrates on a shaft rigidly secured to the bedplate in solid boxes, or this shaft itself vibrates in these solid bearings, which are Babitted or bushed with brass.

Engines with an Independent Bearing.—As cylinders increase in size, "taking off" the power from the shaft by means of large and heavy overhanging pulleys becomes impracticable; the wheels must be supported between bearings, and then only one bearing can be made secure to bedplate. Bedplates so constructed are modifications of one of three types—the box, the girder, or the Porter-Allen bed; these in their simplest forms are shown by Figs. 8, 9, 10, 11 and 12, and 13 and 14 respectively.

The box bed, the oldest form, is still in use; it makes a cheap engine, for it is easily cast, the planing is quickly done, and as its main bearing, guides, cylinder, and valve guide are bolted to one surface the engine can be rapidly assembled. The casting of such a bed is either for a right or left-hand engine, but not for both, although one pattern for both can be used, if a slight change of blocks and core points be made before placing in the sand. Figs. 15 to 17 show a modification of this bed, the bearing and lower slide are cast on; the valve stem guide shown in Figs. 18 and 19 is peculiar to this design.

The girder bed or frame was employed originally by Mr. Corliss; it is peculiarly well adapted for engines of long stroke, of which his is the leading type. It is usually made independent of main bearing and cylinder, and has the guides cast in. A casting can be used for either a right or left-hand engine; if the engine is symmetrically designed and constructed it can be converted from right to left-hand even when completed. This has been accomplished a number of times to the writer's knowledge. Fig. 21 shows how it is done; the main bearing being symmetrical, the girder is turned over and the cylinder turned end for end, which enables the shaft to be extended to the other hand.

The guides employed with this type of bed are either bored flat or V-shaped; Mr. Corliss employed the V-shape, the angle being 45 deg.; the other forms are largely used. The V enables the wear to be taken up laterally as well as vertically, it requires more skill to machine it than the others, and does not retain oil as well on its surfaces as the flat guides. The bored guide has the advantage of being cheaply machined. It possesses, however, a disadvantage. When a series of engines is being manufactured, the fewer the number of different details employed the better; engines of different strokes with the same bore are demanded by the trade, especially Corliss engines; compound engines, with long strokes of the "side-by-side" type, are built, employing existing frames and "running gears." It is obvious, then, that if the same crosshead can be used for long as well as for the short strokes, a reduction in number of different parts can be made. The vertical space between the outer end of the guides must be sufficient to clear the connecting-rods for long strokes; this means deep crossheads. If now a bored guide is used for a deep crosshead, the vertical web of girder has to be thrown out far enough to clear the boring head, when the guides are being bored; this is a great enough distance to throw the web out of the line of strain between the cylinder and main bearing, it also gives a cumbersome appearance to the design. For this reason the flat slide which can be used with any depth of crosshead is preferable; it is easily planed, retains the lubricant, and offers the least frictional resistance; the vertical web of girder can lie in a straight line,

MODERN FRENCH ARTILLERY; BALLISTICAL DATA OF NAVAL GUNS (CANET SYSTEM), MODEL 1889.

TABLE LXXIV.—PARTICULARS OF 24-CENT. (9.45-IN.) GUNS. CONSTRUCTED BY THE FORGES ET CHANTIERS DE LA MEDITERRANEE.

Length of Gun			25 Calibres.		30 Calibres.		36 Calibres.		43 Calibres.		50 Calibres.	
Calibre			in. 9.45	mm. 240	in. 9.45	mm. 240	in. 9.45	mm. 240	in. 9.45	mm. 240	in. 9.45	mm. 240
Total length of gun			236.2	6000	283.5	7200	340.2	8640	406.3	10,320	472.5	12,000
Weight of gun			tons 13.979	kilos. 14,200	tons 19.096	kilos. 19,400	tons 22.649	kilos. 23,000	tons 30.612	kilos. 31,100	tons 34.451	kilos. 35,000
,, shell			lb. 374.8	170	lb. 374.8	170	lb. 374.8	170	lb. 374.8	170	lb. 374.8	170
,, charge			127.9	58	160.9	73	198.4	90	231.5	105	266.7	121
Muzzle velocity			ft. 1772	metres 540	ft. 2001	metres 610	ft. 2231	metres 680	ft. 2428	metres 740	ft. 2624	metres 800
,, energy			foot-tons 8157.2	m. tons 2526.6	foot-tons 10,410	m. tons 3224.1	foot-tons 12,937	m. tons 4006.5	foot-tons 15,320	m. tons 4744.8	foot-tons 17,905	m. tons 5545.3
Remanent velocities at	yds. 547	m. 500	ft. 1660	metres 506	ft. 1903	metres 580	ft. 2123	metres 647	ft. 2310	metres 704	ft. 2506	metres 764
	1094	1000	1555	474	1808	551	2018	615	2195	669	2391	729
	1641	1500	1460	445	1722	525	1919	585	2083	635	2280	695
	2188	2000	1368	417	1637	499	1824	556	1975	602	2172	662
	2735	2500	1283	391	1558	475	1735	529	1873	571	2067	630
Striking energy at	547	500	foot-tons 7162.8	m. tons 2218.5	foot-tons 9411.0	m. tons 2914.8	foot-tons 11,712	m. tons 3627.1	foot-tons 13,867	m. tons 4294.3	foot-tons 16,330	m. tons 5057.3
	1094	1000	6285.1	1946.7	8524.8	2640.1	10,582	3277.2	12,521	3878.0	14,868	4604.7
	1641	1500	5540.0	1715.8	7711.8	2388.2	9574.5	2965.3	11,246	3482.8	13,513	4185.2
	2188	2000	4864.7	1506.7	6965.8	2157.5	8647.8	2678.6	10,140	3140.1	12,261	3797.2
	2735	2500	4276.7	1324.6	6311.5	1954.9	7828.7	2424.7	9,122	2825.1	11,105	3439.0
Striking energy in foot and metric tons per inch and per cent. of circumference of shell	At muzzle		277.1	33.79	353.7	43.12	437.8	53.38	520.5	63.46	608.3	74.17
	547	500	243.5	29.67	319.1	38.91	397.8	48.51	471.0	57.43	554.8	67.64
	1094	1000	213.6	26.04	289.6	35.81	359.5	43.83	425.4	51.86	505.1	61.58
	1641	1500	188.3	22.96	261.9	31.94	325.3	39.66	382.0	46.58	459.1	55.97
	2188	2000	165.3	20.15	236.6	18.85	293.8	35.82	344.5	42.00	416.5	50.78
	2735	2500	145.3	17.72	214.5	26.15	266.0	32.43	309.9	37.78	393.6	47.99
Thickness of wrought-iron plate penetrated (Gâvre formula)	At muzzle		in. 17.60	cm. 44.7	in. 20.95	cm. 53.2	in. 24.45	cm. 62.1	in. 27.28	cm. 69.3	in. 30.43	cm. 77.3
	547	500	16.03	40.7	19.45	49.4	22.80	57.9	25.71	65.3	28.90	73.4
	1094	1000	14.61	37.1	18.15	46.1	21.58	53.8	23.90	60.7	27.01	68.6
	1641	1500	13.23	33.9	16.54	42.0	19.73	50.1	22.13	56.2	252.1	64.1
	2188	2000	12.16	30.9	15.71	39.9	18.35	46.6	20.56	52.2	235.5	59.8
	2735	2500	11.10	28.2	14.64	37.2	17.69	43.4	19.06	48.4	219.3	55.7
Range at different angles	deg. 3		yards 2,646	metres 2,420	yards 3,209	metres 2,935	yards 3,729	metres 3,410	yards 4,221	metres 3,860	yards 4,653	metres 4,255
	5		4,006	3,665	4,483	4,465	5,632	5,150	6,244	5,710	6,823	6,240
	7		5,424	4,960	6,337	5,795	7,256	6,635	7,883	7,290	8,644	7,905
	10		7,174	6,560	8,283	7,575	9,361	8,560	10,078	9,215	10,961	10,025
	15		9,607	8,785	10,940	10,005	12,203	11,160	13,160	12,035	14,048	12,845
	20		11,520	10,535	13,067	11,950	14,450	13,215	15,506	14,180	16,440	15,035
	25		12,969	11,860	14,733	13,475	16,211	14,825	17,310	15,830	18,288	16,725
	30		13,970	12,775	16,093	14,635	17,530	16,030	18,671	17,075	19,677	17,995
	35		14,636	13,385	16,895	15,450	18,459	16,880	19,622	17,945	20,640	18,875

TABLE LXXV.—PARTICULARS OF 32-CENT. (12.60-IN.) GUNS. CONSTRUCTED BY THE FORGES ET CHANTIERS DE LA MEDITERRANEE.

Length of Gun			25 Calibres.		30 Calibres.		36 Calibres.		43 Calibres.		50 Calibres.	
Calibre			in. 12.60	mm. 320	in. 12.60	mm. 320	in. 12.60	mm. 320	in. 12.60	mm. 320	in. 12.60	mm. 320
Total length of gun			315.0	8000	377.9	9600	453.8	11,520	542.0	13,760	629	16,000
Weight of gun			tons 33.14	kilos. 33,700	tons 45.25	kilos. 46,000	tons 53.48	kilos. 54,400	tons 72.6	kilos. 73,800	tons 81.6	kilos. 83,000
,, shell			lb. 881.8	400	lb. 881.8	400	lb. 881.8	400	lb. 881.8	400	lb. 881.8	400
,, charge			299.8	136	377.2	172	467.4	212	551.1	250	626.1	284
Initial velocity			ft. 1770	metres 540	ft. 2000	metres 610	ft. 2230	metres 680	ft. 2424	metres 740	ft. 2625	metres 800
Striking energy			foot-tons 19,197	m. tons 5944.94	foot-tons 24,498	m. tons 7586.11	foot-tons 30,440	m. tons 9427.1	foot-tons 36,048	m. tons 11164.08	foot-tons 42,131	m. tons 13047.9
Remanent velocities at	yds. 547	m. 500	ft. 1705	metres 520	ft. 1925	metres 587	ft. 2144	metres 654	ft. 2341	metres 714	ft. 2535	metres 773
	1094	1000	1640	500	1853	565	2066	630	2256	688	2450	747
	1641	1500	1580	482	1784	544	1990	607	2171	662	2372	723
	2188	2000	1522	464	1719	524	1915	584	2089	637	2291	699
	2735	2500	1462	446	1655	505	1843	562	2013	614	2220	677
Striking energy at	547	500	foot-tons 17,800	m. tons 5512.72	foot-tons 22,682	m. tons 7024.83	foot-tons 28,159	m. tons 8720	foot-tons 33,560	m. tons 10393.36	foot-tons 39,331	m. tons 12182
	1094	1000	16,457	5096.82	21,016	6508.14	26,127	8091.8	31,161	9650.21	36,731	11376.80
	1641	1500	15,295	4736.46	19,482	6033.34	24,255	7511.6	28,850	8934.61	34,407	10657.03
	2188	2000	14,173	4389.30	18,073	5597.86	22,452	6953.2	26,711	8272.53	32,165	9961.26
	2735	2500	13,093	4055.36	16,790	5199.27	20,791	6439.1	24,818	7685.93	30,171	9344.09
Striking energy in foot and metric tons per inch and per cent. of circumference of projectile ..	At muzzle		489.2	59.69	624.3	76.17	777.0	94.74	920.0	112.10	1014.3	131.02
	547	500	453.8	55.35	578.3	70.54	718.3	87.64	855.5	104.36	1002.5	122.32
	1094	1000	419.2	51.15	534.7	65.25	666.6	81.32	794.0	96.90	936.5	114.23
	1641	1500	389.8	47.56	496.8	60.58	618.8	75.49	735.8	89.71	877.0	107.01
	2188	2000	361.2	44.07	460.9	56.21	572.6	69.88	681.6	83.06	820.0	100.01
	2735	2500	333.7	40.72	428.0	52.21	530.7	64.72	632.2	77.17	769.0	93.82
Thickness of wrought-iron plate penetrated (Gâvre formula)	At muzzle		in. 26.4	cm. 67.1	in. 31.46	cm. 79.9	in. 36.73	cm. 93.3	in. 41.43	cm. 105.2	in. 45.83	cm. 116.4
	547	500	25.04	63.6	29.77	75.6	34.77	88.3	39.33	99.9	43.78	111.1
	1094	1000	23.66	60.1	28.15	71.5	32.96	83.7	37.24	94.9	41.80	106.1
	1641	1500	22.49	57.1	26.69	67.8	31.26	79.4	35.36	89.8	39.78	101.0
	2188	2000	21.27	54.0	24.92	63.3	29.57	75.1	33.43	84.9	38.19	97.0
	2735	2500	20.12	51.1	24.01	61.0	27.99	71.1	31.74	80.6	36.49	92.7
Range at different angles	deg. 3		yards 2,761	metres 2,525	yards 3,385	metres 3,095	yards 3,997	metres 3,655	yards 4,527	metres 4,140	yards 5,031	metres 4,600
	5		4,237	3,875	5,217	4,770	6,080	5,560	6,797	6,215	7,491	6,850
	7		5,780	5,285	6,841	6,255	7,906	7,230	8,776	8,025	9,593	8,775
	10		7,721	7,060	9,028	8,255	10,313	9,430	11,213	10,255	12,309	11,255
	15		10,461	9,565	12,073	11,040	13,626	12,460	14,833	13,565	15,978	14,610
	20		12,680	11,565	14,539	13,295	16,272	14,880	17,622	16,115	18,853	17,240
	25		14,319	13,095	16,490	15,080	18,356	16,785	19,784	18,090	21,074	19,270
	30		15,490	14,165	17,965	16,445	19,936	18,230	21,421	19,590	22,758	20,810
	35		15,835	14,480	19,031	17,405	21,051	19,250	22,570	20,640	23,926	21,880

connecting the cylinder to the main bearing, and the casting can be made in green sand without cores.

One well-known builder uses a double-bored slide, as shown by Fig. 20; he has devised two parallel boring bars one for the top and the other for the bottom guide, these operate simultaneously on the bed; by this device the deep crosshead and vertical web are retained.

The Porter-Allen bed, Figs. 13 and 14, is an extremely rigid and well-designed form; it is specially adapted to high rotative speeds, as its broad base, bolted for the entire length to the foundation prevents yielding. The locomotive slide is used with it; the cylinder overhangs the end. Separate patterns have to be made for right and left-hand castings.

A modification of this design is shown by Figs. 5, 6, and 7, where a bored guide is used instead of the locomotive; this form might be said to be a combined girder and Porter-Allen. There are a number of special designs varying between these two types.

MODERN FRENCH ARTILLERY.
No. XLIX.

THE CANET SYSTEM OF FIRING TORPEDOES.

THE efficient method of firing torpedoes, either from large vessels or from torpedo boats, is too important a part of modern naval armament to have been overlooked by the Forges et Chantiers de la Mediterranée. This class of ordnance, for it can be fairly classified under the general head of artillery, is chiefly made at the company's works at Le Havre and La Seyne, from the designs of M. Canet, which have been modified and improved from time to time until the early models of 1882 and 1883 have but little in common with the latest patterns, such as were shown at the Paris Exhibition of 1889. The problem to be solved is not an easy one, as important causes for disturbing the direction to be given to the torpedo have to be reckoned with and overcome. Once free from such influences, the motive power of the torpedo carries it forward with more

TABLE LXXVI.—BALLISTICAL DATA OF 34-CENT. NAVAL GUNS (CANET SYSTEM). CONSTRUCTED BY THE FORGES ET CHANTIERS DE LA MEDITERRANEE.

Length of Gun			25 Calibres.		30 Calibres.		36 Calibres.		43 Calibres.		50 Calibres.	
			in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.
Calibre			**13.39**	340	**13.39**	340	**13.39**	340	**13.39**	340	**13.39**	340
Total length of gun .. .			**334.7**	8500	**401**	10,200	**482**	12,240	**576.3**	14,620	**669**	17,000
			tons	kilos.	tons	kilos.	tons	kilos.	tons	kilos.	tons	kilos.
Weight of gun			**39.76**	40,400	**54.23**	55,100	**64.76**	65,800	**87.10**	88,500	**98.42**	100,000
			lb.		lb.		lb.		lb.		lb.	
" shell			**1058**	480	**1058**	480	**1058**	480	**105.8**	480	**1058**	480
" charge			**352.7**	160	**440.9**	200	**573.2**	260	**661.4**	300	**749.6**	340
			ft.	metres	ft.	metres	ft.	metres	ft.	metres	ft.	metres
Initial velocity			**1772**	540	**2001**	610	**2231**	680	**2423**	740	**2624**	800
			foot-tons	m. tons	foot-tons	m. tons	foot-tons	m. tons	foot-tons	m. tons	foot-tons	m. tons
Striking energy			**22,800**	7061.68	**29,096**	9011.14	**36,479**	11297.9	**42,820**	13261.33	**50,048**	15498.88
	yds.	m.	ft.	metres	ft.	metres	ft.	metres	ft.	metres	ft.	metres
Ramanent velocities at	**547**	500	**1710**	521	**1932**	589	**2151**	656	**2345**	715	**2539**	774
	1094	1000	**1649**	503	**1862**	568	**2077**	633	**2266**	691	**2460**	750
	1641	1500	**1593**	486	**1796**	548	**2004**	611	**2188**	667	**2331**	726
	2188	2000	**1535**	468	**1735**	529	**1935**	590	**2111**	644	**2305**	703
	2735	2500	**1481**	452	**1675**	511	**1865**	569	**2040**	622	**2230**	680
			foot-tons	m. tons	foot-tons	m. tons	foot-tons	m. tons	foot-tons	m. tons	foot tons	m. tons
Striking energy at	**547**	500	**21,221**	6572.49	**27,125**	8400.88	**33,650**	10421.30	**39,979**	12380.21	**46,840**	14508.40
	1094	1000	**19,790**	6129.32	**25,227**	7812.40	**31,331**	9703.75	**37,567**	11563.62	**43,985**	13622.06
	1641	1500	**18,470**	5720.05	**23,482**	7272.36	**29,190**	9040.21	**34,784**	10774.14	**41,210**	12764.78
	2188	2000	**17,124**	5303.52	**21,875**	6775.92	**27,195**	8429.94	**32,428**	10042.79	**38,640**	11968.04
	2735	2500	**15,975**	4947.53	**20,418**	6323.05	**25,320**	7841.46	**30,251**	9369.56	**36,151**	11197.94
Striking energy in foot and metric tons per inch and per cent. of circumference of projectile ..	At muzzle		**548.0**	66.81	**699.0**	85.25	**869.0**	105.94	**1027.5**	125.46	**1200.0**	146.63
	547	500	**509.8**	62.18	**650.4**	79.47	**803.0**	98.59	**961.0**	117.12	**1125.0**	137.26
	1094	1000	**475.2**	57.98	**606.0**	73.91	**752.8**	91.80	**896.4**	109.40	**1056.0**	128.87
	1641	1500	**444.0**	54.11	**564.0**	68.80	**701.3**	85.52	**835.2**	101.93	**990.0**	120.76
	2188	2000	**411.3**	50.17	**525.1**	64.10	**653.6**	79.75	**779.0**	95.01	**929.0**	113.22
	2735	2500	**383.7**	46.80	**490.4**	59.82	**608.0**	74.18	**726.6**	88.64	**869.0**	105.94
			in.	cm.	in.	cm.	in.	cm.	in.	cm.	in.	cm.
Thickness of wrought-iron plate penetrated (Gâvre formula)	At muzzle		**28.62**	72.7	**34.1**	86.6	**39.71**	100.8	**44.68**	113.3	**49.48**	125.6
	547	500	**27.20**	69.1	**32.41**	82.3	**35.94**	96.0	**42.62**	108.2	**47.20**	119.8
	1094	1000	**25.86**	65.7	**30.87**	78.4	**35.94**	91.3	**40.66**	103.2	**44.63**	113.8
	1641	1500	**24.64**	62.6	**29.25**	74.3	**34.18**	86.8	**38.70**	98.3	**43.40**	110.1
	2188	2000	**23.24**	59.03	**27.80**	70.6	**32.27**	84.5	**36.81**	93.5	**41.55**	105.4
	2735	2500	**22.21**	56.40	**26.45**	67.2	**30.87**	78.4	**35.04**	89.0	**39.71**	100.8
	deg.		yards	metres	yards	metres	yards	metres	yards	in.	yards	metres
Range at different angles	3		**2,788**	2,550	**3,423**	3,130	**4,024**	3,680	**4,599**	4,205	**5,227**	4,780
	5		**4,287**	3,920	**5,293**	4,840	**6,184**	5,655	**6,933**	6,340	**7,857**	7,185
	7		**5,861**	5,360	**6,949**	6,355	**8,071**	7,380	**8,967**	8,200	**9,825**	8,985
	10		**7,852**	7,180	**9,202**	8,415	**10,554**	9,650	**11,486**	10,505	**12,630**	11,550
	15		**10,662**	9,750	**12,340**	11,285	**13,969**	12,775	**15,237**	13,935	**16,440**	15,035
	20		**12,915**	11,810	**14,888**	13,615	**16,713**	15,285	**18,141**	16,590	**19,435**	17,775
	25		**14,642**	13,390	**16,910**	15,465	**18,887**	17,270	**20,395**	18,650	**21,765**	19,905
	30		**15,844**	14,490	**18,459**	16,880	**20,520**	18,765	**22,121**	20,220	**23,521**	21,520
	35		**16,664**	15,240	**19,551**	17,880	**21,679**	19,825	**23,301**	21,310	**24,757**	22,640

or less accuracy, to the object aimed at. The causes of deviation are of course more serious on large vessels than in torpedo boats, because in the latter the most favourable position can be chosen for discharging the missile, and the surrounding body of water affected by the boat moving rapidly has not so great a mass as that set in motion by a large ship travelling at a high speed. If the torpedo be discharged within this zone of disturbing influence, it is evident that its course will be diverted to a greater or less extent. Torpedoes fired from a moving ship at an angle to its line of advance, will of necessity participate in the movement, which introduces another cause of error. The first difficulty can be overcome by projecting the torpedo beyond the belt of troubled water surrounding the ship; when it is not possible to discharge it parallel to the axis of the boat, the general practice is to allow the torpedo to fall upon the water either flat or to enter it at a slight angle, so that it may at once penetrate under the surface waves and so escape any deviating influence they may exert. Both systems are employed in the French Navy, and the method is well illustrated by Fig. 511, page 3, which is taken from an instantaneous photograph of a torpedo being discharged from the French warship Condor.

The earlier form of this kind of gun is clearly explained by Figs. 512 to 520, page 6, which are general and detailed drawings of the Canet system as carried out in 1883.

Fig. 512 is a perspective view of the complete gun ready for service; Fig. 513 is a longitudinal section of the breech end of the tube and the back part of carriage, and also a side view of fore part of tube and longitudinal section of front part of carriage; Fig. 515 is a back elevation of the breech end of tube and carriage; Fig. 517 is a plan of the fore part of carriage; Fig. 520 is a plan of back part of carriage; Fig. 514 is a side elevation of firing mechanism; Fig. 518 shows another combination of discharging mechanism; Fig. 519 is a cross-section of tube at the trunnion of the fore carriage; Fig. 516 a cross-section of tube showing the starting catch H; Fig. 521 is a section through M N of the powder chamber.

The discharging mechanism consists of a system of levers and a spiral spring P that is tightened by acting on the crank lever O″ by means of a handspike that fits one of the extremities. This lever O^2 is kept cocked by the catch lever Q, the safety pin q preventing any sudden release of the mechanism. On the same axis on which is keyed the crank lever O^2 are fixed two other levers; one the lever O^1 that releases the torpedo inside the tube, and the other the lever O that works the firing mechanism.

The actual working of the whole arrangement for launching is as follows:

We will suppose that a torpedo has just been discharged. The gunner, by means of a handspike fixed at the end of the crank lever O″, Fig. 514, tightens the spring P; he also puts in the safety pin q, and then, to open the breech, he catches hold of the small hand lever K and gives one-sixth of a turn to the screw that closes the breech. The threads of this screw are partly cut away like those of an ordinary breech-block, then, on pulling the lever K towards him, the whole of the breech swings round the hinge J″, Fig. 514, and the gun is ready to receive a torpedo which is introduced carefully into the tube, whilst the stop bolt I, Figs. 513 and 514, inside the tube, is lowered by means of the hand lever i until the torpedo is well home; when the man lets go the hand lever i, the spring i'' is liberated, and the bolt I maintains the torpedo inside the tube.

The charge of gunpowder or any other explosive is then put into the powder chamber or cup L; this chamber is pierced with holes radiating from its centre so that the gases rush against the inner surface of the tube, thus preventing any damage to the torpedo.

The breech is closed by swinging it round the hinge J″ till it is home, then by the handle K the screw of the breech is turned one-sixth round, care being taken to release the catch K′ in pressing with the thumb on the spring.

To prevent the escape of gases the breech presses a ring of leather or asbestos let into the internal face of the breech. In order to introduce a new fuze the hammer m, Figs. 513 and 514, must be pulled out and pushed down the inclined planes, and the fuze is then put in. The gun so loaded is ready for a new discharge. If the breech is not well closed the end of the lever O will not enter into the slot of the hammer, and the fuze could not be exploded. This mechanism is therefore also a safety arrangement. To fire, the gunner pulls out the safety pin q, and by exerting a slight effort towards him with the handle of the catch lever Q, he releases the spiral spring P. The rotary motion imparted to the axis that carries the three-crank levers before described, removes first the stop bolt I inside the tube and immediately afterwards explodes the fuze. The exploding of the fuze is produced as follows: On the slide piece m', Fig. 515, is fixed the hammer m, which carries on each side a stud. The slide piece is pushed upwards by the lever o. This tightens the spring m'', and when the studs are at the summit of the inclined planes the hammer is released, and strikes the fuze, which explodes. Inside the tube, and fixed at a proper distance, is the usual spring catch H, Fig. 516, which acts on the starting valve of the engines inside the torpedo itself as it is shot from the tube. The above arrangement has been described for a percussion fuze. In some cases an electric fuze is used, and it is by the sliding up of the piece m that the circuit is closed and the charge exploded. The construction of the carriage is as follows:

The front part of the carriage consists of a crosshead B, bearing the trunnions B, Figs. 513 to 519; this crosshead turns round on a pivot resting on a strong bracket C, so that it can be fixed for firing either at the fore or aft part of the ship or broadside.

The hind part or breech end of the carriage consists of a V-shaped frame E d d, Figs. 513 to 517, which rests on two rollers e, that may turn when required in any vertical position. The front beam E of this frame has a hole in its centre to let the elevating screw G pass through it.

This screw G is fastened to a lug under the tube, and it is worked up and down by the nut e'' cast with the handwheel g. The nut itself turns in two half bearings e''' provided with horizontal trunnions working in the front beam E.

The front and rear parts of the carriage are kept together by means of the connecting-rod D. This rod at its front end turns horizontally round the bracket C, and is attached to it by means of the collar c. At its rear end the rod is attached to the V-shaped frame by means of the collar d^2, and the extreme end of the connecting-rod turns in a socket provided in the beam E.

This mode of connecting the rod to the rear part of the carriage allows the V frame and rollers to follow the slope of the deck without interfering with the laying of the tube.

Figs. 521 to 524, pages 6 and 7, illustrate the latest types of the Canet torpedo firing tubes; Figs. 521 and 524 are elevations of that form of tube designed with the special object of forcing the projected missile to fall flat on the surface of the water, instead of at an angle. The firing tube, which is of light section and made of either bronze or steel, is prolonged above with a spoon-shaped extension. A T-shaped groove is made in the top of the bore, for the greater part of its length, and in this groove slides a projection formed in the upper side of the torpedo. The groove is made of such a length that when the projection is free from it, the torpedo is guided only by the extension of the tube, and is in a horizontal position; it is then free to fall flat on the water. Tables LXXIV. to LXXVI., give ballistical particulars of naval guns, Canet system, of 24, 32, and 34-centimetre calibre.

DULUTH.—The lake commerce of Duluth, at the head of Lake Superior, flourished during the season just closed, the tonnage having increased nearly 300,000 tons.

TORPEDO-FIRING APPARATUS, CANET SYSTEM.

(*For Description, see Page 4.*)

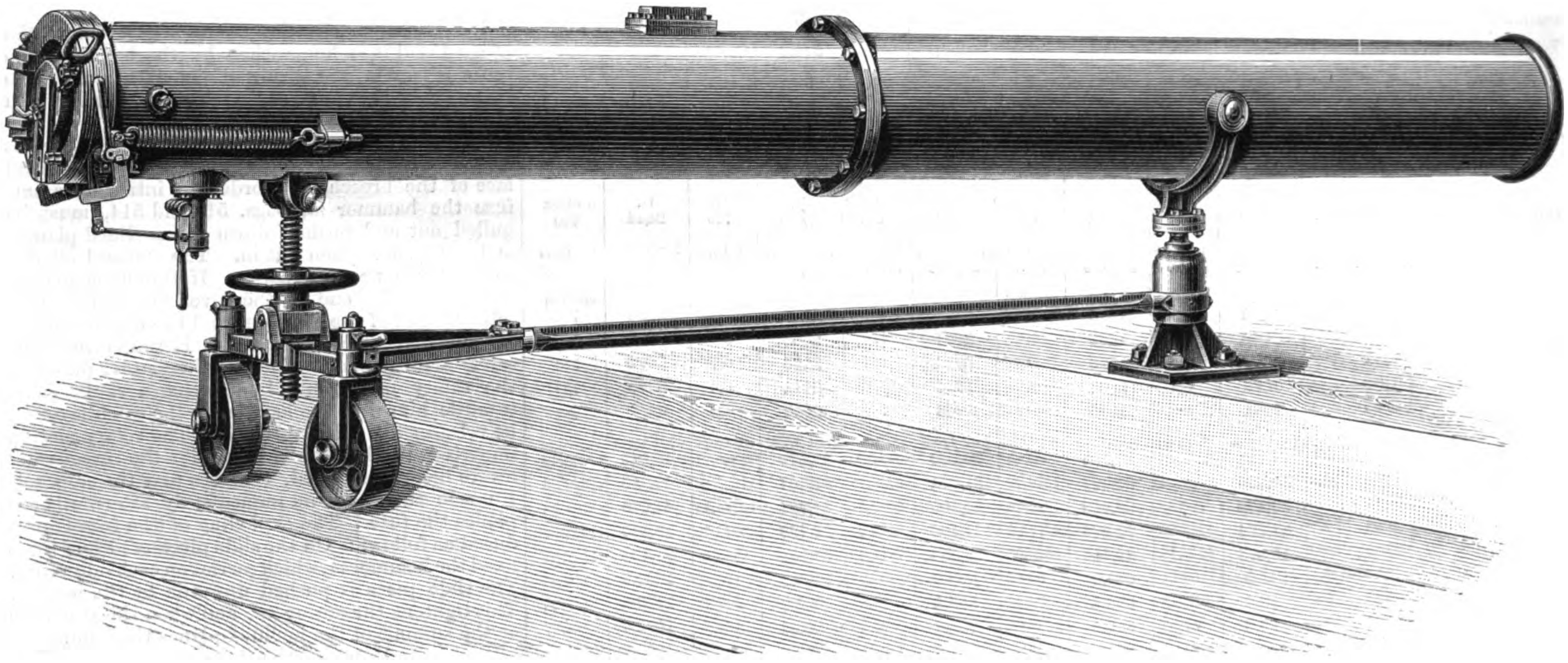
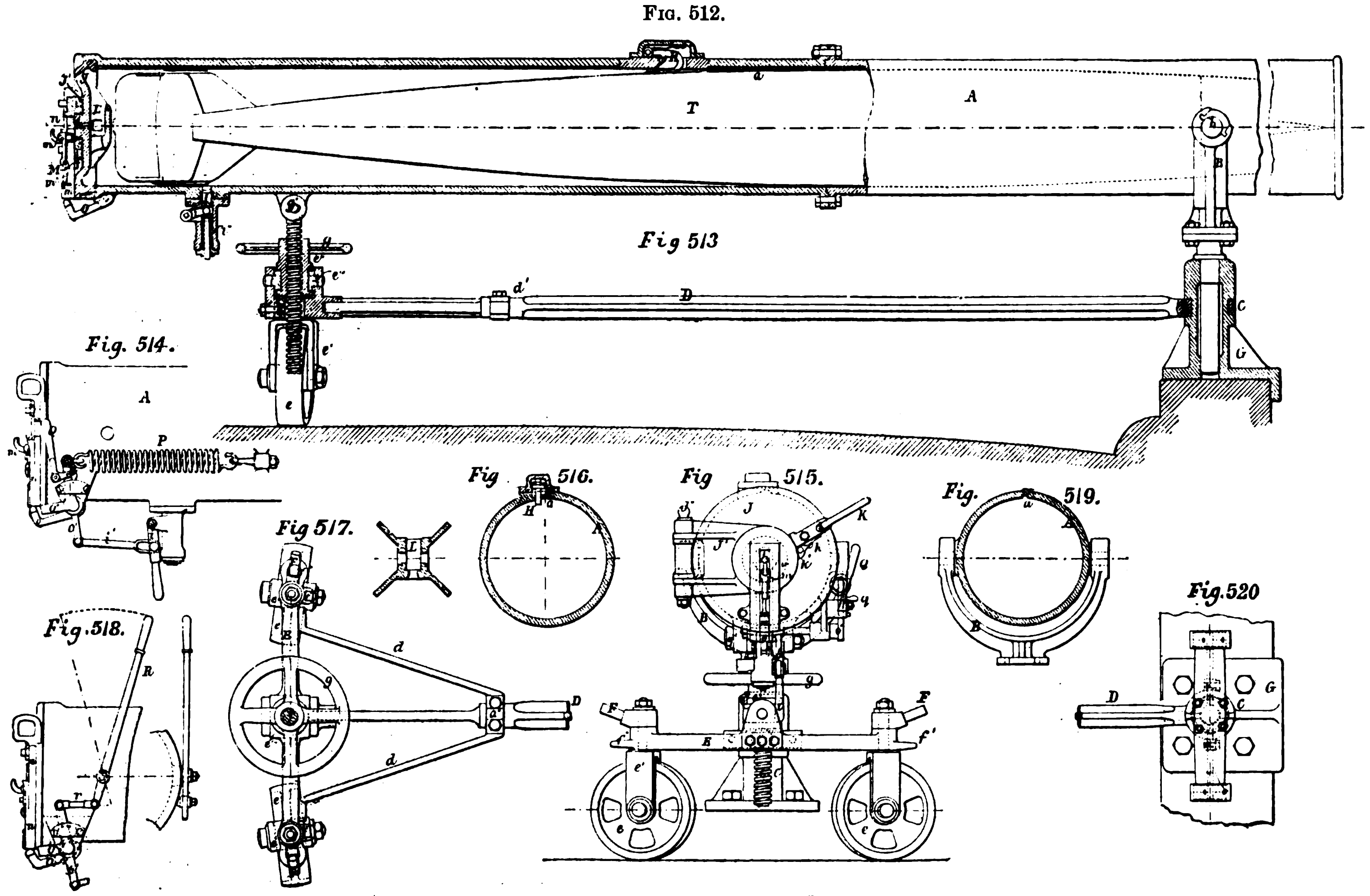
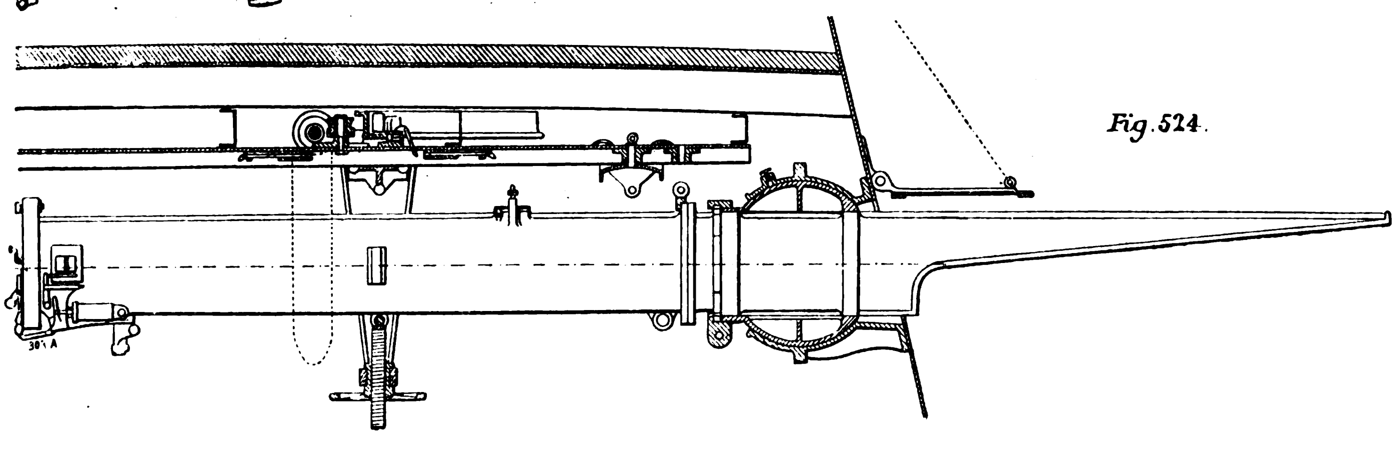


FIG. 512.





TORPEDO-FIRING APPARATUS, CANET SYSTEM.

(*For Description, see Page 4.*)

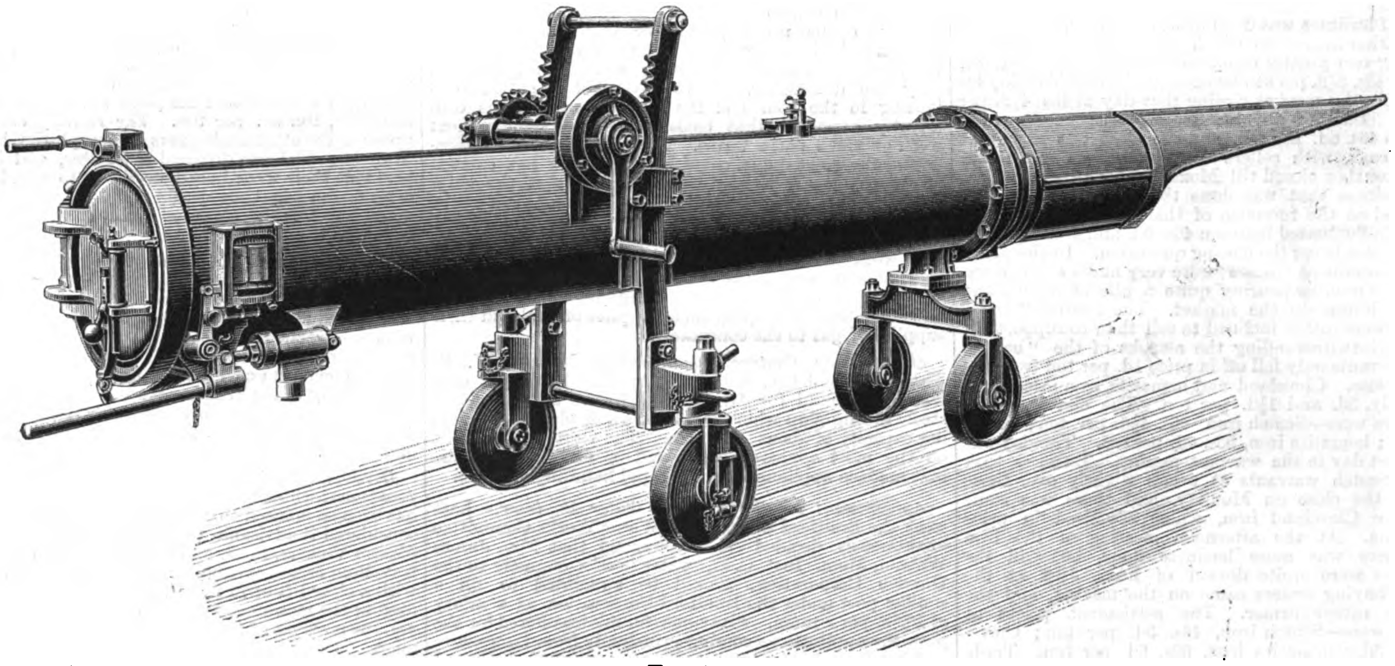


FIG. 521.

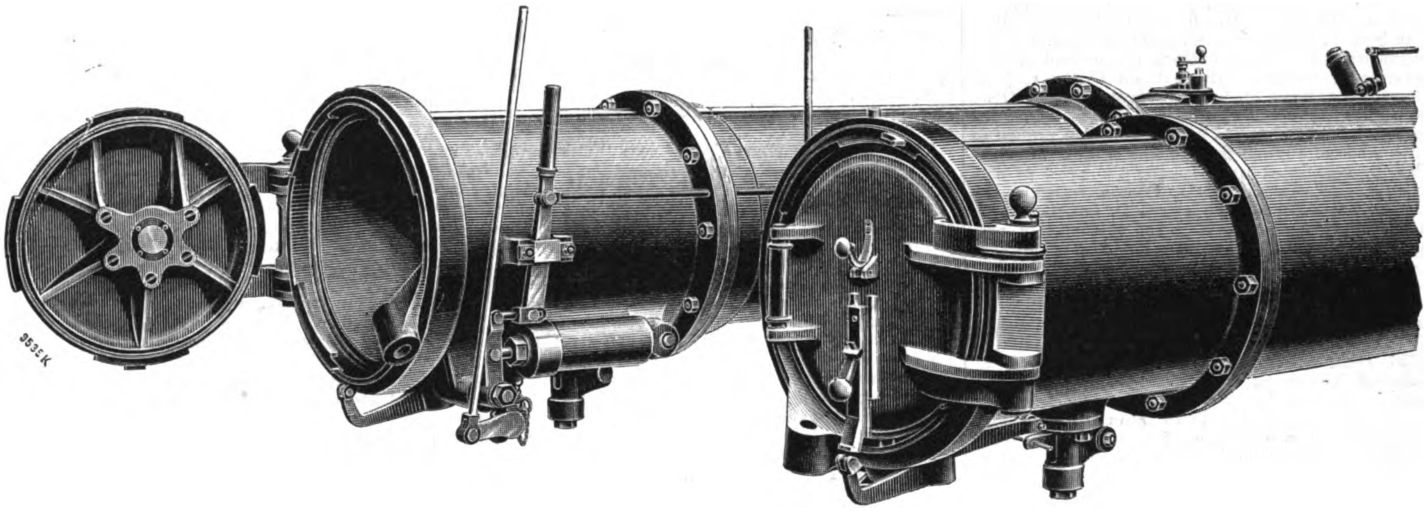


FIG. 522.

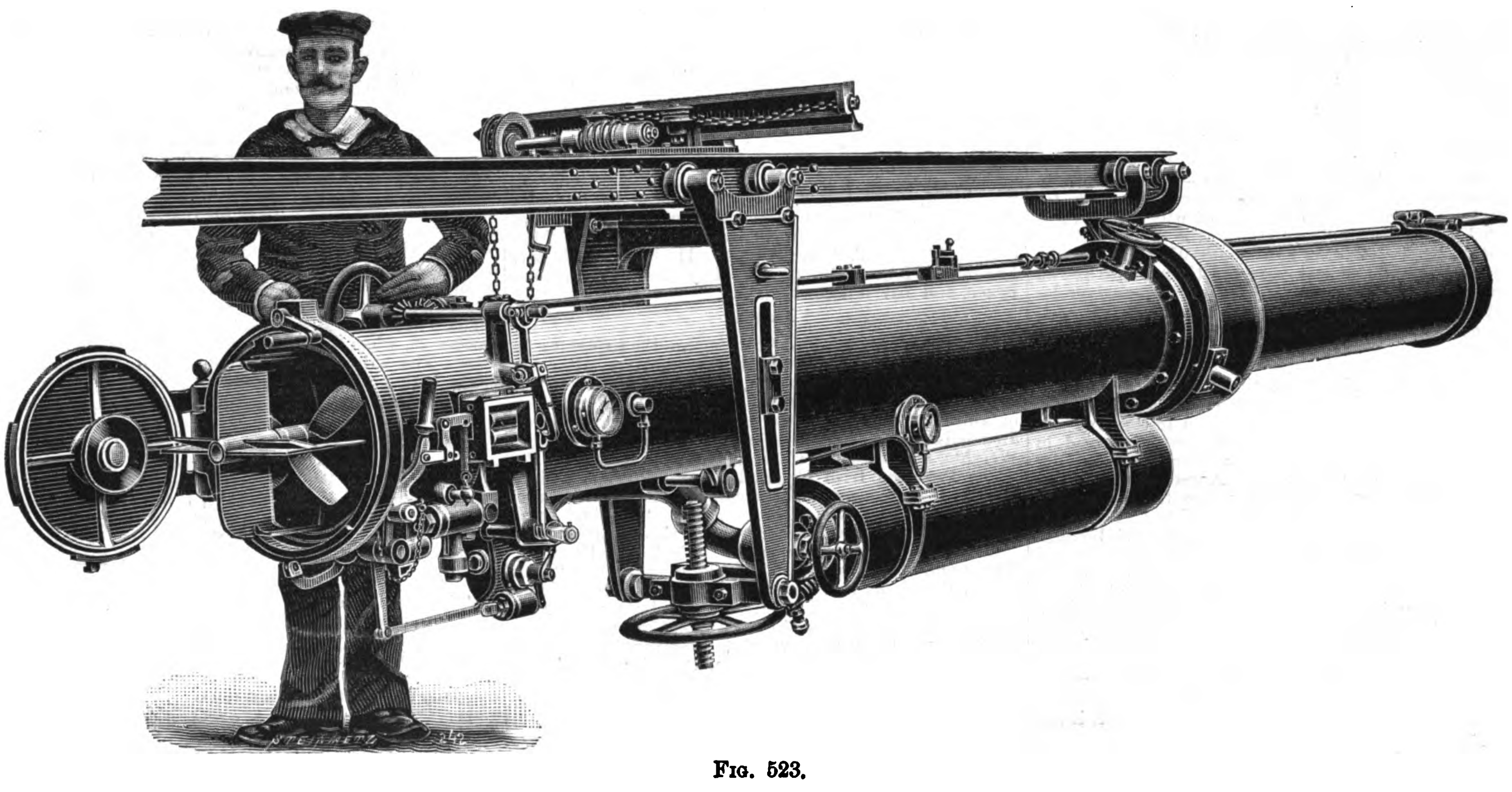


FIG. 523.

another beyond being bound in the same volume or series of volumes, and having occasional references to so and so on such and such a page in some other portion of the work. This fragmentary character and lack of coherence in works on metallurgy have, doubtless, much to do with the development of an impression that metallurgy was not entitled to the distinction of being regarded as a separate and definite subject, but that it was rather a name given to that particular branch of practical chemistry which deals with the extraction of metals. Moreover, the effect of this literature on the student is unsatisfactory, for although much of the matter in many of these works on metallurgy, *inter alia* the works of Percy, Phillips, Bauerman, Lowthian Bell, &c., is of the highest importance, and in fact indispensable to those who aspire to any proficiency in the subject, yet we have noticed that the effect produced on the mind of students by reading them is in most instances similar to that produced by the perusal of encyclopedia articles, and an impression is acquired that metallurgy consists of various incoherent descriptions of processes with no other link to hold them together, except the fact that a furnace of some sort plays some part in each description. It seems that the present volume is intended to check this unsatisfactory state of things.

The object of the present volume, so appropriately named "An Introduction to the Study of Metallurgy," we gather, is to inculcate into the mind of the reader the principles upon which the art of metallurgy in general is based. In fact to provide the student henceforth with a logical, substantial, and general foundation upon which he will be able to erect, out of the material supplied in the treatises already referred to, a mental metallurgical edifice in which all the various branches will be gathered together and united in intimate association under one roof, and supported on the same solid foundation of identical principles. The subject matter therefore, instead of being arranged under the names of the metals, in the manner to which we are accustomed, is subdivided in the following manner: The relation of metallurgy to chemistry; physical properties of metals; alloys; the thermal treatment of metals; fuel; material and products of metallurgical processes; furnaces; means of supplying air to furnaces; typical metallurgical processes; economic considerations.

In the opening chapter the objects of metallurgy are explained; whilst the antiquity and gradual development of the art and the indebtedness of chemistry to it are tersely impressed on the reader in a historical sketch, relating to the recorded observations on the behaviour of lead under the combined influence of heat and air, extending from periods most remote up to the present age. And the reader is led to regard metallurgy as distinct from chemistry, for although it admittedly makes liberal use of that science, yet it serves other sciences just the same, and in fact its eclecticism constitutes one of its characteristics; for instance, Dr. Percy has said in connection with the many contributory sciences called into the services of metallurgy that the list is calculated to excite not a little apprehension in the mind of the metallurgical student when he commences his labours. The reader of the present volume may, however, proceed fearlessly, inasmuch as this diverse knowledge, whether chemical, physical, or mechanical, is suitably systematised and prepared ready for the digestion of the metallurgist.

The second chapter furnishes information relating to the characters of useful metals, more especially those properties of practical utility which have to be developed and kept constantly in view by the metallurgist when preparing the metals for general or particular purposes; we are glad to see that among these the measurement of tensile strength is duly included and considered. In the next chapter the properties of metals when in mutual association are extensively and forcibly discussed; it also includes the elucidation of the interesting phenomena of the variations produced in the properties of metals by minute quantities of impurities, a subject which the author has made particularly his own, and it is clearly demonstrated that whether they be due to allotropism or to other causes, the phenomena are manifestly of considerable importance to the metallurgist; the following, page 74, is an interested example of the vagaries of allotropism: "A quantity of buttons consisting mainly of tin, and intended for the adornment of military uniforms, were safely delivered by the manufacturer and placed in store. On inspection, however, the military authorities found nothing but a shapeless mass of grey powder, for the tin had assumed its allotropic form and the buttons had disappeared." An ingenious and fascinating mechanical explanation based on the relative atomic volumes is given for the occurrence of these derangements in the molecular structure of metals by the application of homœopathic doses of impurities. This section of the book must prove of interest to all readers whether regarded from a metallurgical or chemical point of view. A pleasant little digression, which, however, is worked in as an example of the flow of metals, introduces some of the results of the author's researches in the region of Japanese art metal work, and this interesting chapter is brought to a close with a list of the compositions of several of the most important alloys employed in various industries.

In the chapter on the behaviour of metals under thermal treatment, which next receives attention, the historical portions are of much interest. The molecular movements of iron as influenced by heat, the origination of the idea of α and β iron, of hardening and combined carbon and of recalescence as well as the present views on these points, are successively and lucidly dealt with; perhaps a few more words might have been profitably devoted to the diagram, page 101. The classification of steels upon a hardening and tempering basis is set forth with due prominence, and its importance demonstrated; take as an example the description, page 117, of the remarkable effect of a little carbon more or less "in the highly carburised steel used for the manufacture of dies, such steel should contain 0.8 to 1 per cent. of carbon and no manganese . . . . and a really good die will strike 40,000 coins of average dimensions without being fractured or deformed, but if the steel contain 0.1 per cent. too much carbon, it would not strike 100 pieces without cracking, and if it contained 0.2 per cent. too little carbon, it would probably be hopelessly distorted and its engraved surface destroyed in the attempt to strike a single coin." Interesting, too, to the practical man is the industrial application of the phenomenon or recalescence, page 110.

The reader is now transferred from the region of hard thinking to the more practical department, such as the measurement of heat and the various materials available for its production and the modes of employing them; then the materials at the disposal of the metallurgist for the production of metals, ores, and fluxes, and the products they give rise to, are fully discussed, and lead in due course to the consideration of furnaces, charges, and various processes by which numerous desired results may be attained and incidentally the industrial value of slags is referred to. There is a laudable endeavour on the part of the author to restrict the terms "wasting" and "calcination," page 173, to distinct operations, but, nevertheless, we notice that it does not appear compatible with the significance already attached to those words in practice, *q.v.*, pages 242-244, 250, 264, &c.

A new departure is taken at this stage; hitherto in the book the chemical and physical requirements of the metallurgist have been dealt with, but now some of the other requirements are presented to the reader, and furnaces, their various forms and characters, and the ways and means of supplying them with air, are duly described, illustrated, and explained. Finally, the practical application of the principles laid down is exemplified by brief, in fact too brief, notices of some typical and more complicated metallurgical processes in use not alone in our own country, but also in other parts of the world. The diagrammatic representations are an excellent introduction, and demonstrate very clearly the relation of the various sub-departments to one another, and to the general plan of operations in the various work, but altogether this portion of the book cannot be considered as successful as the preceding sections, principally on account of excessive condensation.

The author's views on metallurgical instruction are good and are in accord with our own. The concluding chapter contains some useful economic considerations relating to: The relative position of capital, knowledge and labour in industry; the product of metals and their market prices. It appears that as regards metallurgical works various methods have been adopted for giving the workmen a prominent interest in the works; in the most successful of the arrangements enumerated the men receive a share in profits, part of which is distributed annually, the remainder being invested.

There are many good illustrations, and the very large number of references to original memoirs not alone constitute of themselves a valuable aid to any who wish to pursue their studies, but also give some idea of the enormous amount of care and trouble the author has expended in the preparation of this work.

We have thus endeavoured to indicate the scope and character of this little volume, which is remarkable for its originality of conception and for the large amount of information it contains, including as it does notices of views dating back to remotest antiquity and of researches of more recent times, whilst the burning questions of the day, far from being neglected, are dealt with in a manner suitable to their importance.

We consider, therefore, that Professor Roberts-Austen, to whom already metallurgy is deeply indebted, has now rendered another valuable service to this highly important art. To those conversant with the professor's lectures and contributions to metallurgical learning this small record of some of his work and views will be most welcome and requires no recommendation, and to others we cannot but recommend everybody who desires information on the subject not alone to consult but also to study the contents of this book.

BOOKS RECEIVED.

Ninth Annual Report of the United States Geological Survey to the Secretary of the Interior, 1887-88. By J. W. POWELL, Director. Washington: Government Printing Office.

The Railroad, Telegraph, and Steamship Builder's Directory. New York: The Railway Directory Publishing Company.

Report on Observations on Railways and other Subjects made during a Tour in 1883 under the Direction of the Government of South Australia. By HENRY C. MAIS, M. Inst. C.E., Engineer-in-Chief of South Australia. Adelaide: E. Spiller, Government Printer.

Geological Features of the Transvaal, South Africa. By CHARLES J. ALFORD, F.G.S. With Maps and Illustrations. London: Edward Stanford.

Forth and Clyde Ship Canal in Relation to the Development of Commerce. By J. LAW CRAWFORD. Glasgow and London: Maclaren and Sons.

Screws and Screwmaking, with a Chapter on the Milling Machine. With 95 Illustrations. Colchester: The Britannia Company.

Nystrom's Pocket-Book of Mechanics and Engineering. Revised and corrected by WILLIAM DENNIS MARKS, Ph. B. Twentieth Edition, revised and greatly enlarged with Original Matter. London: Charles Griffin and Co.

MODERN FRENCH ARTILLERY.
No. LIX.

HOTCHKISS QUICK-FIRING GUNS—*continued.*

FIGS. 639 and 640 (see next page) show another form of carriage for the 10-centimetre gun; it is formed with parallel plate-iron sides mounted on coned rollers, which traverse around a circular deck plate; the upper side of the carriage is inclined and forms slides for the gun, up which it mounts under the action of the recoil; the movement is checked by the combined action of a powerful spring secured to the carriage, and by pressure cylinders which are charged with vaseline.

The illustrations show this arrangement clearly, as well as the training gear and protecting shield. Referring to the carriage for the 10-centimetre gun, published by us in our last issue (see page 273), we should mention that this design, as well as some others adopted by the Hotchkiss Company, is due to Messrs. Armstrong and Co., of Newcastle.

It was in 1886, after considerable experience had been gained with the smaller calibres of rapid-firing guns, that the first attempt was made by the Hotchkiss Company to considerably increase them, and the gun we have just described, as well as the 65-millimetre (2.56-in.), was the result. The main condition in design that was kept in view in constructing these larger natures, was that they should be built, not only on the same principle as the smaller ones, but that so far as possible no deviation should be made in detail, except that of size. We have described the changes which increase of bore and weight made necessary for the 10-centimetre gun, and it will be seen that for the 2.56-in. their differences were yet more trifling. As regards the gun itself, the material used was the same—oil-tempered Creusôt steel, of high resistance and large elasticity; the inner tube is, however, reinforced by one jacket in a single piece, and on which the trunnion rings

HOTCHKISS 10-CENTIMETRE (33-POUNDER) QUICK-FIRING GUN AND NAVAL MOUNT

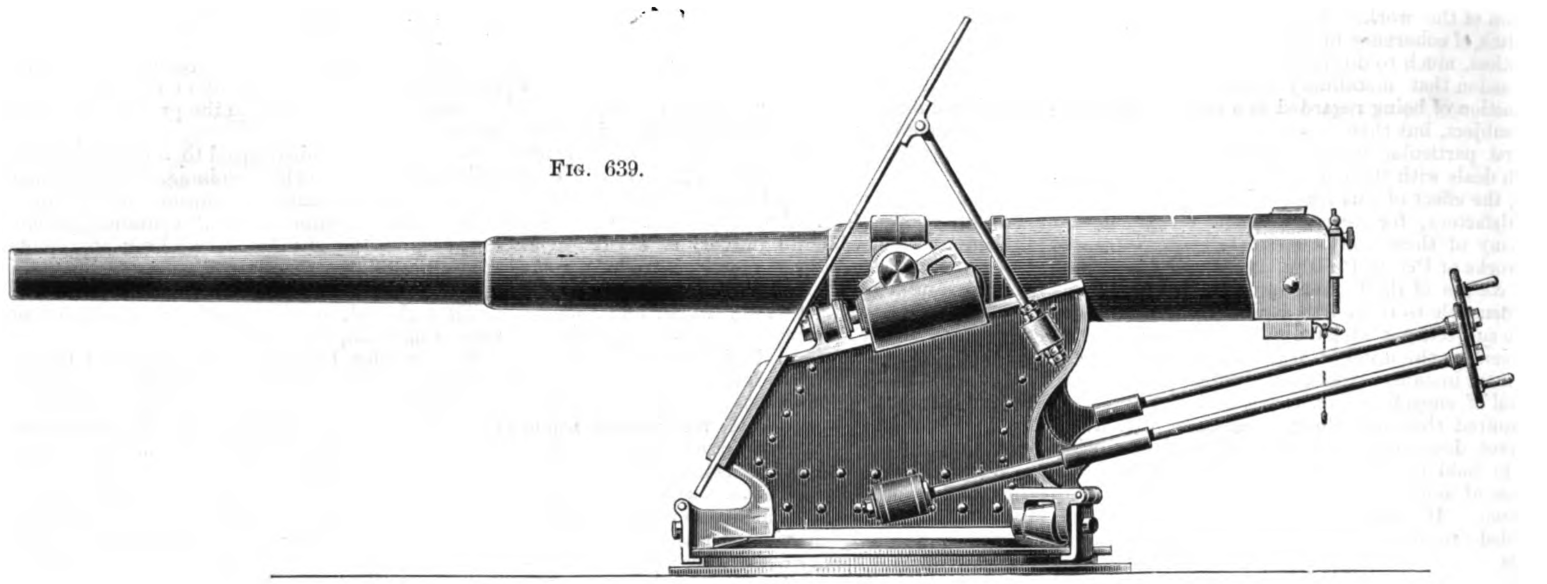


FIG. 639.

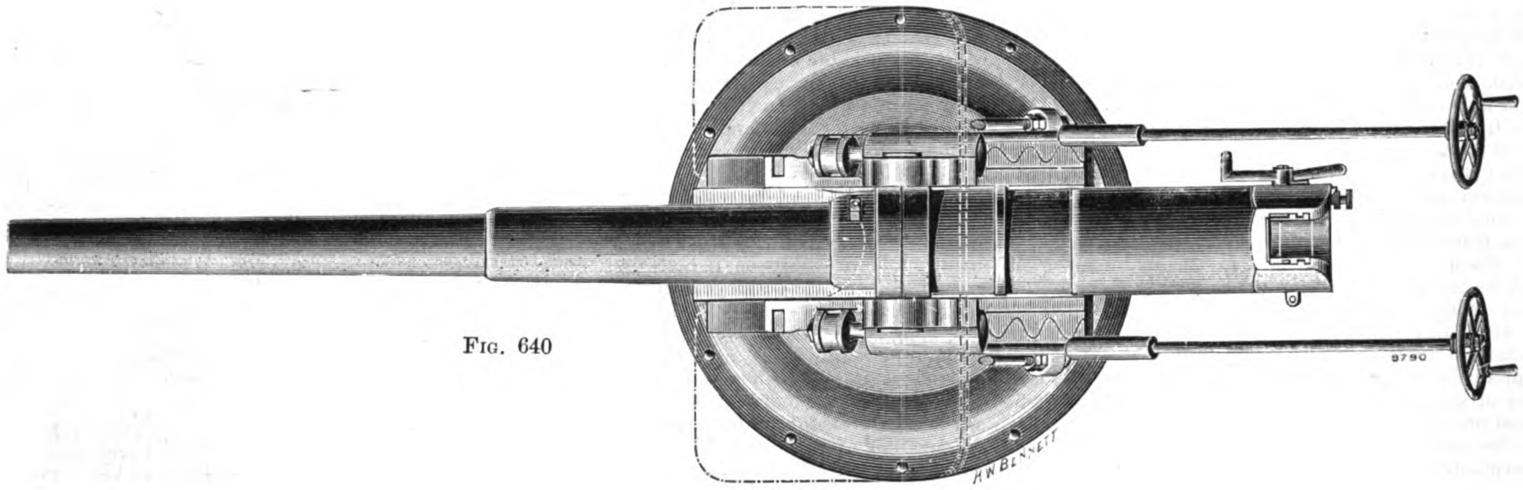


FIG. 640

are forged (see Fig. 567, page 181 *ante*); the forward end of this jacket is terminated by a light finishing ring carrying the forward sight; of the breech-closing mechanism it is not necessary to speak here, as it has been already fully described. The duty for which the gun was designed was to throw a projectile weighing about 9 lb., with an initial velocity of 2016 ft. and a maximum rapidity of twenty shots per minute. The total length of bore is 111.14 in. and the extreme length of gun 119.09 in.; the number of grooves is twenty-six, the width 5.9 millimetres, the depth .4 millimetre, and the pitch increasing from 0 deg. to 6.30 deg. Fig. 642 and Figs. 633 to 638, page 273 *ante*, show methods of mounting this gun, the form of carriage employed being also used for some of the mountings of smaller calibres. The stand rests on a steel deck ring, and flat bars rising at varying angles are bolted to it, converging at the top where they are bolted to a heavy socket casting, within which the foot of the mount rests; this foot is supported by a step in the base of the socket, and is free to turn in any direction horizontally, while it can be locked at any desired angle by a screwed lever in the socket. The upper part of the support terminating in the foot is forked and provided with trunnion bearings to carry the trunnions of the cradle in which the gun itself is mounted. The cradle, as in that of the 10-centimetre gun, is provided with two flat slides on which the gun trunnions rest; to the castings carrying the trunnion are connected the brake cylinders similar to those already described, and illustrated in Fig. 633; the capacity of the hydraulic cylinders, in which oil is used, is about 2¼ quarts; the proportion of these cylinders and the strength of the compressor springs are arranged to limit the recoil to 5 in. No training gear need be applied to this gun, as the elevation and direction can be given wholly by the shoulder-piece. The firing arrangement consists of a tube attached to the shoulder-piece, and through which the firing lanyard is passed, so that it is ready to the hands of the gunner as soon as the gun is brought to bear (see Fig. 642). Of course the shoulder-piece is attached to the side of the cradle, and is quite unaffected by the recoil of the gun. We shall speak of the firing performance of this gun on another occasion, but meantime we append the principal particulars of the piece, its ammunition, and mount.

TABLE XCVII.—*Particulars of 65-Millimetre Rapid-Firing Gun.*

1. *Gun*:	
Diameter between lands	2.56 in.
,, of rear of powder chamber	3.15 ,,
,, trunnions	3.54 ,,
,, face of muzzle	3.94 ,,
Length of rifled part of bore ...	91.85 ,,
Total length of bore	111.14 ,,
Length of travel of projectile in bore	94.49 ,,
Extreme length of gun	119.09 ,,
Length from face of muzzle to end of shoulder-piece	144.68 ,,
Length from trunnion centres to end of shoulder-piece	60.16 ,,
Length from face of breech to end of shoulder-piece	34.56 ,,
Number of grooves	26
Width of grooves	.23 in.
Depth ,, ...	.15 ,,
Pitch of rifling, increasing from ...	0 to 6.30 deg.
Length of line of sight	50.55 in.
Distance of line of sight from axis of bore; horizontal	4.13 ,,
Distance of line of sight from axis of bore; vertical	5.05 ,,
Weight of breech-block	73 lb.
Total weight of gun	1320 ,,
2. *Mountings*:	
Weight of frame stand	836 ,,
,, pivot	308 ,,
,, cradle	528 ,,
,, shoulder-piece	73 ,,
Total weight of mount	1745 ,,
,, ,, gun and mount in position	3065 ,,
Height of trunnion centre above deck	43.5 in.
Vertical range of fire	+ or − 15 deg.
3. *Ammunition*:	
(*a*) Steel shell:	
Total length	9.8 in.
Ratio of weight to cast-iron ball of same diameter	4.02 ,,
Weight of empty shell	8.25 lb.
,, bursting charge ...	.31 ,,
,, fuze	.14 ,,
Total loaded weight	8.8 ,,
(*b*) Common shell:	
Total length	9.4 in.
Weight of empty shell	8.42 lb.
,, bursting charge ...	.24 ,,
,, fuze	.14 ,,
Total loaded weight	8.8 ,,
(*c*) Case shot:	
Number of balls	169
Weight of each ball...	1.1 oz.
,, case shot...	9.39 lb.
Weight of empty cartridge case ...	3.3 ,,
,, powder charge	3.63 ,,
,, wad	.02 ,,
,, loaded cartridge (steel shell)	15.75 ,,
Weight of loaded cartridge (common shell)	15.75 ,,
Weight of loaded cartridge (case shot)	16.25 ,,
Total length of cartridge (steel shell)	26.69 in.
,, ,, (common shell)	26.3 ,,
Weight of empty ammunition box...	50.6 lb.
,, loaded ,, ,, ...	176 ,,
Number of rounds held in each box	8

The maximum pressures in the powder chamber of this gun range below 15 tons per square inch, and the penetrative power at a range of 100 yards is equal to 6.3 in. of wrought-iron plate.

Fig. 641 is an illustration of a 3-pounder quick-firing gun mounted on a Hotchkiss recoil carriage, and intended for the same kind of service as the Elswick mount shown in Fig. 642. The pivot circle is a single casting of gun-metal, which is either bolted to the deck or secured to it by holding-down

MODERN FRENCH ARTILLERY HOTCHKISS QUICK-FIRING GUNS.

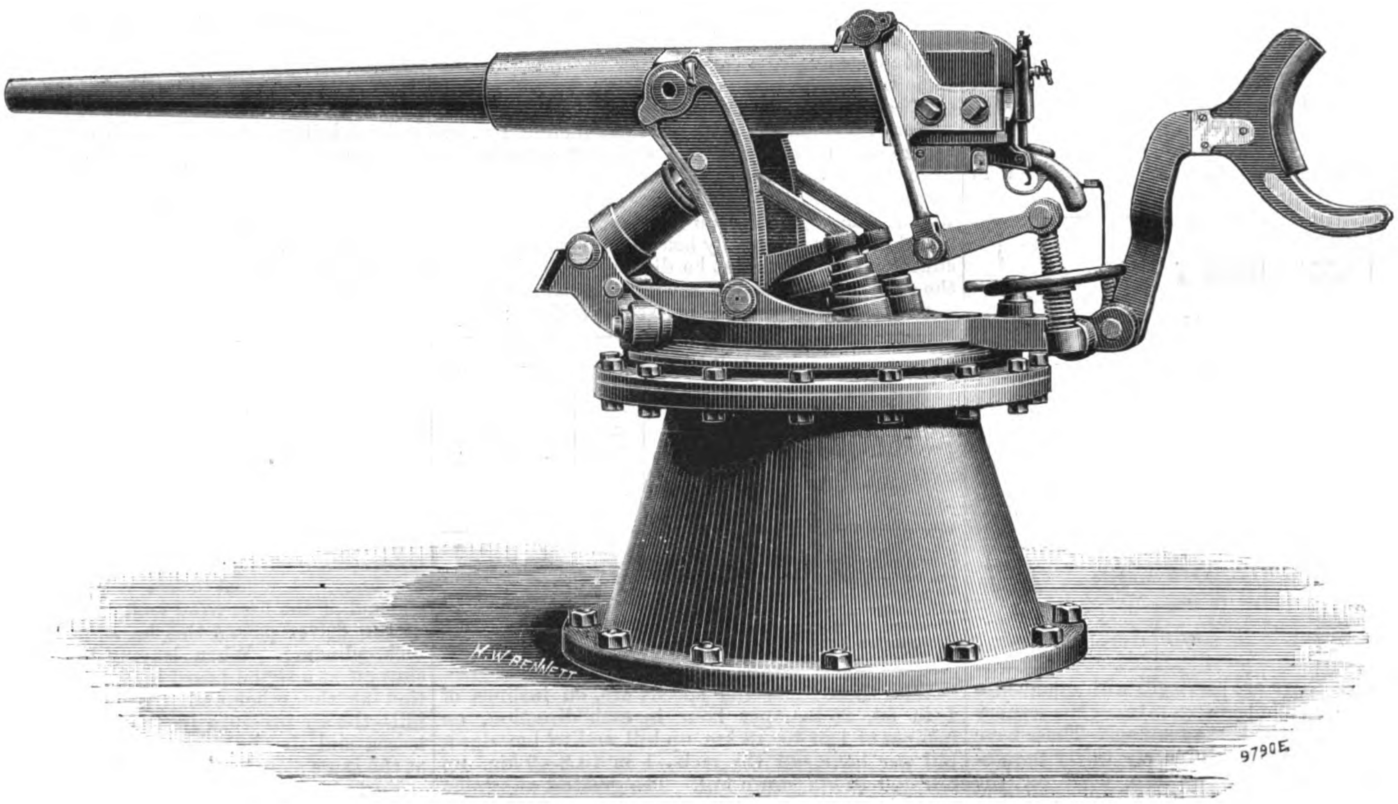


FIG. 641. 3-POUNDER GUN ON RECOIL MOUNT.

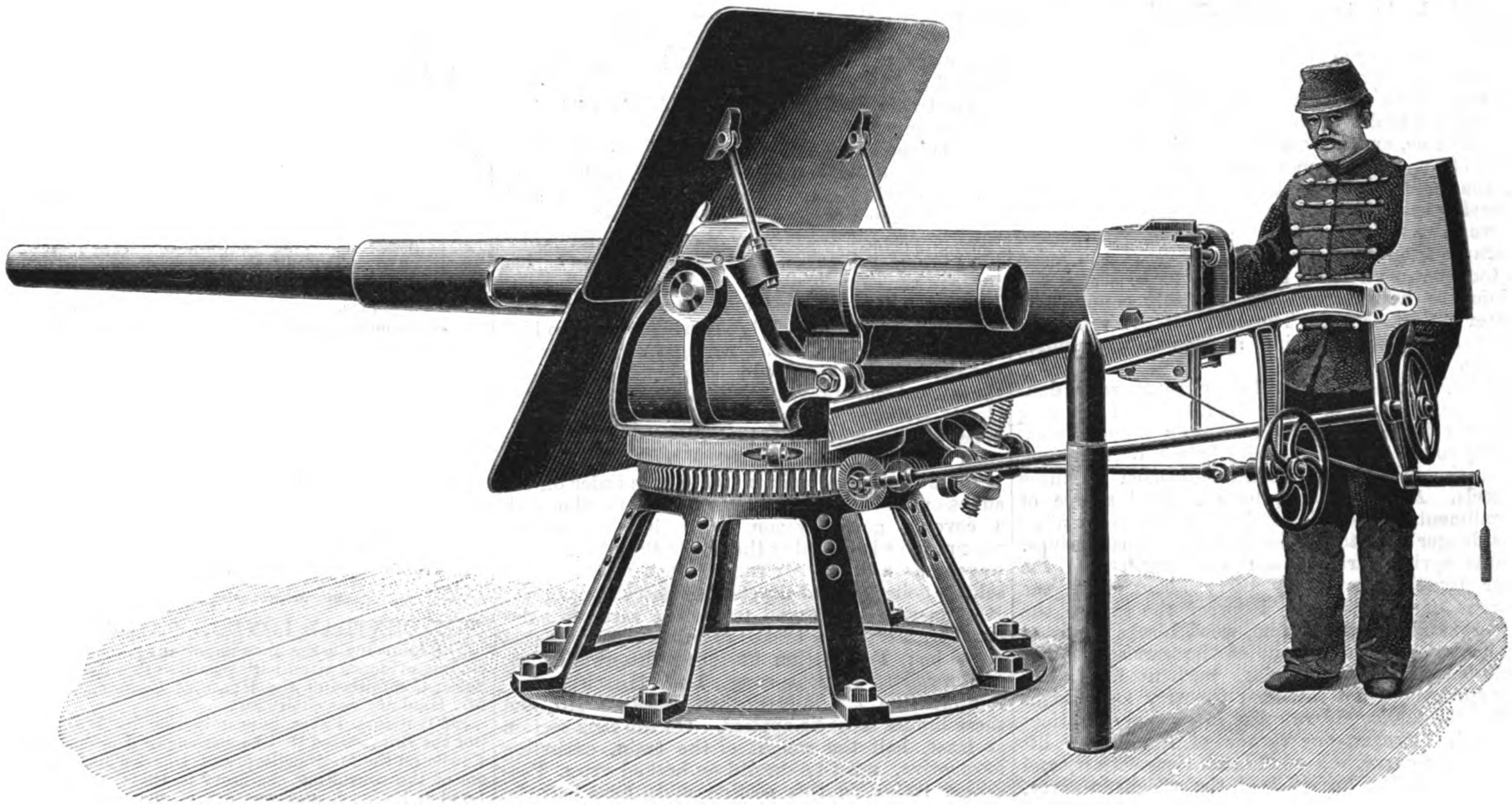


FIG. 642. 65-MILLIMETRE (9-POUNDER) GUN ON NAVAL RECOIL MOUNT.

rings; a short pivot projects from the centre, and through this passes a holding-down bolt. The baseplate is formed of a single gun-metal casting, which is free to turn on the pivot circle, and is kept in place by the holding-down nut and clip placed at the front and rear; gun-metal rollers are placed under the front part of the plate to reduce friction, and to aid in supporting it. The centre and rear of the plate bear direct on the circle, and the front is extended and turned up to form two arms that support the trunnions of the hydraulic cylinder. In front of the pivot, projections are cast on the plate to carry the shaft of the rocking arms, and in corresponding positions at the rear are recesses to receive the recoil springs. The holding-down clip at the rear serves as a compressor, by means of a tightening clamp on the upper end, projecting through the baseplate; to the baseplate the shoulder-piece is bolted and it also carries the socket of the elevating screw. The recoil cylinder is held to the baseplate by small trunnions at its rear end. It is closed at the upper end by a stuffing-box, and a feed hole is provided, closed with a screwed plug. The piston is of smaller diameter than the cylinder, so as to allow the fluid to pass around it during recoil, instead of through holes; the piston-rod passes through the cylinder and its front end is attached to the rocking arms by a bolt. The rocking arms are made of a gun-metal casting and turn on the shaft carried by the lugs in the baseplate; they are connected above by a crossbar through which the piston-rod of the brake cylinder passes. Brackets project from the rear of the arms, as shown, and bear on the coiled springs; these throw the gun forward after recoil. The elevating gear is shown in the engraving, and a bar supporting the breech of the gun is pivotted to the elevating bar, the upper end being attached to a plate bolted on the left-hand side of the breech.

TORPEDO BOAT MOUNTINGS FOR HOTCHKISS QUICK-FIRING GUNS.

FIG. 643

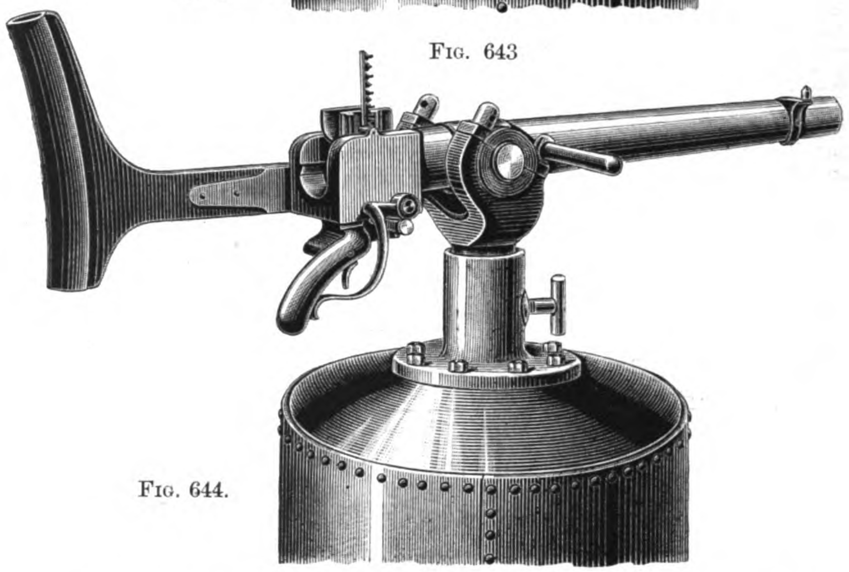


FIG. 644.

FIG. 645.

structed by MM. Riedinger and Co., and which is stated have given very excellent results. A summary of some trials made with them is given in Table VI.; these engines were specially used for working sewing machines and developed on the brake an efficiency of 34.07 and 51.63 foot-pounds per second. In Table VII. are given results of trials made with a half horse-power variable expansion Riedinger engine.

These motors, it may be assumed, represent the best practice that has been obtained up to the present time, in the construction of compressed air motors; with the smallest of them, indicating about one-tenth of a horse-power, the consumption of air, when admitted cold, was 1377 cubic feet and 988 cubic feet when the air was heated before admission. The half horse-power engine consumed 1148 cubic feet of cold air, and of heated air 791 cubic feet per horse-power and per hour. It should be mentioned that these, the most valuable and suggestive of all the trials carried out by Professor Riedler, were conducted with the greatest care, two distinct modes of measuring the air supplied being followed on two occasions for each test; it may therefore be considered that the results given are absolutely correct. Table VIII. summarises the result of trials made with an old single-cylinder Farcot engine nominally of 80 horse-power, but indicating over 72.3. With this engine the consumption of air varied from 465 to 517 cubic feet, the larger consumption being due to the lower temperature (129 deg. Cent.) to which the air was raised before admission; in the most economical result the temperature was 160 deg. Cent. The volumes of air referred to are, of course, in all cases taken at atmospheric pressure.

(*To be continued.*)

MODERN FRENCH ARTILLERY.
No. LX.

HOTCHKISS QUICK-FIRING GUNS—*continued.*

FIGS. 643 to 646 illustrate modifications of mounting the light 37-millimetre Hotchkiss quick-firing guns on torpedo boats, either on the conning tower, as in Fig. 645, or on special supports. The stands in this case consist of a gun-metal pillar made of a simple casting, the top being shaped to form a socket for the pivot, in the upper part of which the trunnions rest, while the bottom has a wide flange by which the stand is bolted direct to the top of the conning tower. The short length of this stand makes the mount too rigid to resist and transmit the firing strains, and to obviate this difficulty the trunnion seats in the pivot are cushioned. Flanged rings are made to fit the trunnion seat of the gun, and are bound with rubber, this binding fitting in

MODERN FRENCH ARTILLERY; HOTCHKISS QUICK-FIRING GUNS.

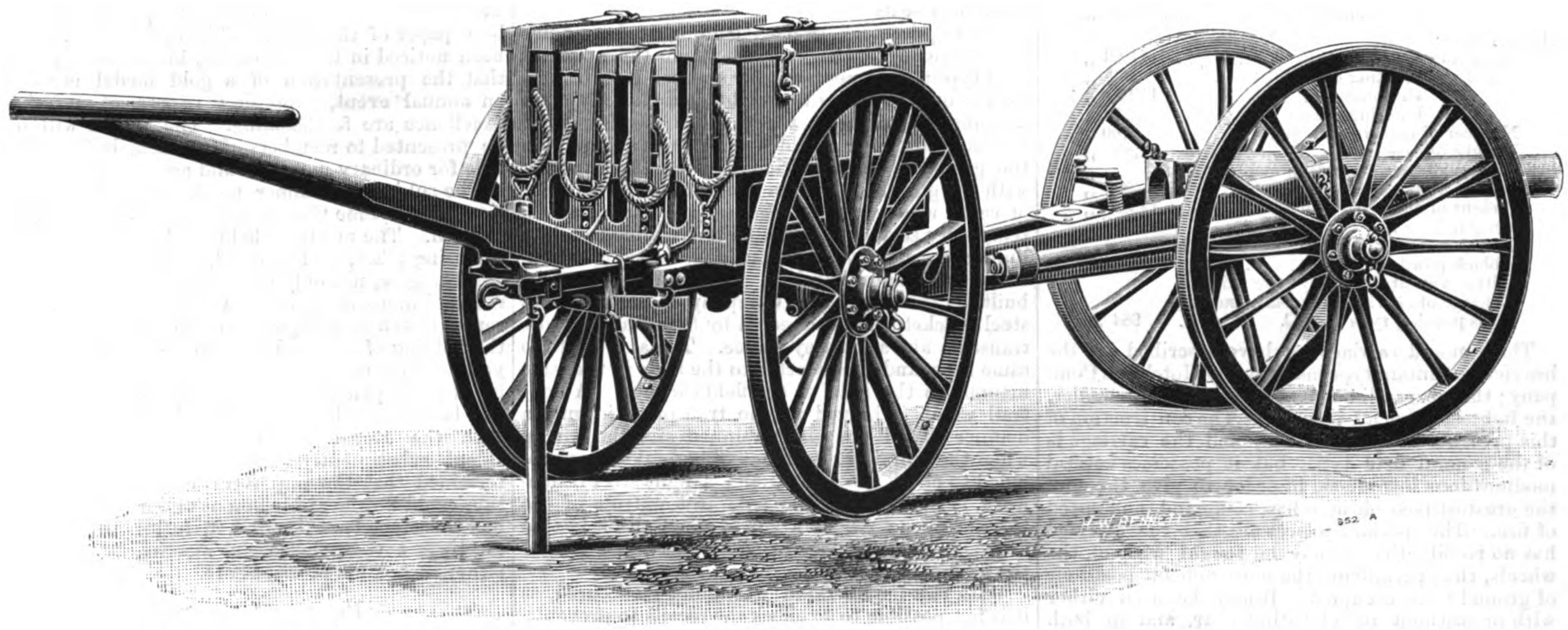


FIG. 647. 12-POUNDER MOUNTAIN GUN CARRIAGE AND LIMBER.

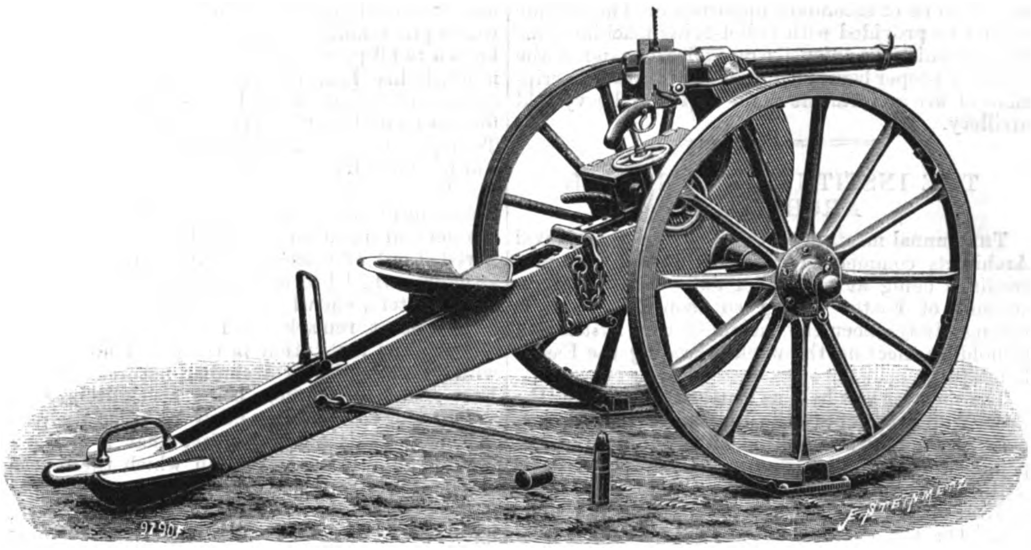


FIG. 648. 1-POUNDER MOUNTAIN GUN AND CARRIAGE.

FIG. 646. 37-MILLIMETRE QUICK-FIRING GUN AND TORPEDO BOAT MOUNT.

the circle formed by the trunnion seat and the cap squares. As is shown in Fig. 645, a circular base may be formed around the stand to contain a supply of ammunition.

Fig. 647 is a general view of the Hotchkiss 76-millimetre (2.99 in.) 12-pounder mountain gun and limber. The body of this gun, like that of the 42-millimetre (1.65 in.) mountain gun, is made of a single block of oil-tempered steel, the trunnion ring being screwed on. The breech mechanism is of the standard type, and is identical with that of the 42-millimetre gun; the ammunition is made on the same plan, that is to say, with a metallic cartridge holding in one, the projectile and the powder charge; the ignition of the charge is effected by means of an ordinary friction primer. On opening the breech the fixed cartridge case is ejected automatically and the gun is then ready for reloading. Three kinds of ammunition are made for this gun, viz., common shell with percussion fuze, shrapnel with combination time and percussion fuze, and case shot. The carriage is of steel throughout, except the wheels, which are of wood with gun-metal hubs and steel tyres. The cheeks of the carriage are flanged and are connected at the front end by a cast-steel transom forming the trunnion bearings and the axle-tree bed in one. In the middle, the cheeks are connected by another transom carrying the elevating gear, and at the end by the trail eye-piece; rope toggle brakes are used to diminish the recoil.

A light limber is sometimes furnished with this gun. It consists of a light steel framework, and carries four of the ordinary ammunition chests holding eight rounds each, besides entrenching tools, &c. The limber is arranged both for manual draught and for mule draught, the shafts, which attach to the trail of the carriage, being also used for the limber when required. For its weight, which is well within the limits allowed for light mountain artillery, this gun is extremely powerful, and the rapidity of fire, which can be obtained with it is about eight to ten rounds per minute. The following are the principal particulars:

TABLE XCVIII.—*Particulars of 76-Millimetre 12-Pounder Hotchkiss Mountain Gun.*

Gun:	
Diameter of bore	2.99 in.
Weight of gun	209 lb.
Length of bore (14 calibres)	41.34 in.
Total length of gun	46.69 ,,
Carriage:	
Weight of carriage without wheels ...	191.5 lb.
,, each wheel	61.6 ,,
Diameter of wheels	37.64 in.
Track ,, ...	28.35 ,,
Height of trunnions above the ground	23.70 ,,
Total weight of carriage	314.6 lb.
Limber:	
Weight of limber body	261.8 ,,
,, wheels	61.6 ,,

Weight of each ammunition chest, empty	30.8 lb.
Total weight of limber with accessories, empty	554.4 ,,
Total weight of limber charged with 32 rounds of ammunition	1005.4 ,,
Ammunition:	
Weight of common shell	11.99 ,,
,, bursting charge	.396 ,,
,, shrapnel	11.99 ,,
,, bursting charge	.110 ,,
Number of balls in shrapnel	160
Weight of case shot	11.99 ,,
Charge of powder (black pebble) for three kinds of ammunition	.88 ,,
Weight of entire cartridge loaded ...	14.08 ,,
Length ,, ,, ...	14.05 in.
Initial velocity of projectile (with black powder)	869 ft.
Initial velocity of projectile with a charge of .462 lb. of French smokeless powder, type B.N.C.	984 ,,

The gun and carriage we have described are the heaviest mountain type made by the Hotchkiss Company; the more ordinary size is considerably smaller, the lightest being a 1-pounder. The construction of this presents no peculiarities, and the carriage is of the general field type, but it possesses several modifications introduced in order to give the gun the greatest possible mobility, command, and speed of fire. The special features are that the carriage has no recoil; that it may be fought without the wheels, thus permitting the most difficult positions of ground to be occupied. It may be used either with or without its elevating gear, and in both cases it has a horizontal sweep, so that the aim may be rectified without moving the trail. The body of the carriage is in two parts, to enable the material to be carried by the *personnel* of a column, each single part being light enough to be carried by one man without difficulty. This gun and carriage are illustrated on Fig. 648.

The Hotchkiss field carriage for quick-firing guns consists of two distinct parts—a main carriage and a top carriage. The main carriage is formed of two bracket sides, connected by transoms, bolts, and a trail plate; a slide for the top carriage; an axle and field wheels. The bracket sides are of steel plate lined with angle steel. The trail plate is of the ordinary field carriage pattern, being provided underneath with a stout spade for resisting recoil. The slide is of steel, provided with small buffers at the front and rear ends; a pivot socket at the front end permits a lateral traverse of about 4 deg. to the right and left of the centre line. The axle is of steel, bedded in the brackets. The wheels are of wood with gun-metal naves and steel tyres. The top carriage is formed of two bracket sides, connected by transoms and held to the slide by stout clips at the bottom edge, and by stout steel springs attached diagonally to the slide in such a manner as to efficiently ease the firing strain on the body of the trail, and whilst allowing a good length of recoil to the top carriage to insure bringing it back to its normal position after firing.

The elevating gear is of an ordinary screw pattern, seated on the left bracket of the top carriage, and connected with the breech of the gun by an auxiliary piece bolted to the left cheek of the breech. The traverse gear of the slide consists of a screw seated in the brackets of the main carriage, and carrying a traveller bolted to the underside of the slide. A directing bar is pivotted to the top of the trail plate. The brake consists of two malleable cast-steel wheel chocks connected by a steel bar, which in turn is connected to the axle-tree by two steel bars, the whole forming a pivotting framework. When not in use the brake is hooked up under the trail; when in action the frame is dropped, the shoes being pushed under the wheels. In limbering up it is simply necessary to start the carriage forward slightly, when the brake comes free of the wheels, and can be hooked up at once. A tool-box is fitted between the main carriage brackets to hold the reserve parts and accessories.

The body of the limber consists of four longitudinal frames, a splinter bar, foot-board, and platform board. The outside frames are of flat steel, the inside ones and the splinter bar being of angle steel; the platform board and foot-board are of oak. A cast-steel limber hook is rivetted between the inside futchells. A pole for double draught is bedded in the body, having a steel swingle-tree and steel splinter bars. The steel axle is secured to its bed in three bearings. The wheels are similar to those of the gun carriage. The limber carries an ammunition chest made of steel plate. The cartridges are carried in boxes of convenient size for transport by two men. (The 3-pounder box holds 21 rounds.) The chest is so arranged that the boxes are drawn out from the rear. The top of the ammunition chest is fitted with a cushion and side rails for cannoneer seats.

The requirements of naval landing service involve modifications in the carriage from the standard field types. The necessity for manual draught calls for the utmost saving in weight possible. Although a limber is provided, the carriage itself is fitted for hand draught, in which case the trail runs on the ground. Ammunition is always transported with the gun, and since in many if not the majority of cases where naval brigades are landed for a temporary service it would be inadvisable to take a limber, arrangements are made for carrying ammunition on the gun carriage. The landing carriage built by the Hotchkiss Company consists of two steel bracket sides connected by breast and middle transoms and a stout eye-piece. The axle is of the same type, and is connected to the body in the same manner as the axle of the field carriage. A light trail wheel is hinged to the trail-piece in such a manner that it may be unpinned and thrown up when the gun is in action. Shoe brakes are provided to check the recoil, and a light steel framework is attached to the axle just outside of the bracket sides to hold a single ammunition box on each side. The limber provided resembles that of the field carriage.

With this mount rapid fire cannot be secured, as it is not possible to so check the recoils to prevent a change of aim; it is assumed that for naval brigade work rapid artillery fire would be such a rare necessity as to be of secondary importance. The brigade should be provided with bullet-firing machine guns which furnish the defensive rapid fire demanded, the artillery proper being required only for such descriptions of fire as form the main object of heavy field artillery.

THE INSTITUTION OF NAVAL ARCHITECTS.

THE annual meeting of the Institution of Naval Architects commenced last Wednesday, the proceedings being at an earlier date than usual on account of Easter falling so soon this year; it having always been the custom of this Institution to hold its meeting the week preceding the Easter holidays.

The meeting was held as usual in the hall of the Society of Arts, lent to the Institution for the purpose. Lord Ravensworth presided. Lord Brassey's paper was read and discussed at Wednesday's sitting and occupied, together with the President's address and the usual formal proceedings, the whole day. On the evening of Wednesday the annual dinner was eaten at the Holborn Restaurant, Lord Brassey presiding in the absence of Lord Ravensworth. The papers of Messrs. Biles, Lewes, and Marchal were on the Thursday morning's programme; whilst Mr. Yarrow's paper was the sole item for the Thursday evening. The remaining papers will be taken at morning and evening sittings of to-day. This year the offers of papers were more numerous than usual, and it was suggested at one time that there should be a Saturday's sitting. This, however, was found to be inexpedient, and in place of it there is to be a second session in London later in the year.

The report of the Council was read by Mr. G. Holmes, the secretary. The balance-sheet showed the income of the Society for the year to be close on 4000*l*., and that a very respectable reserve has now accumulated. The following passage refers to the new departure at Lloyd's with regard to the sub-committee for surveyors: "It was announced in last year's annual report that the Committee of Lloyd's Register of British and Foreign Shipping had met the general views of the shipbuilders and engineers throughout the country by admitting to the sub-committee for surveyors six members of shipbuilding firms and six members of engineering firms, for the purpose of assisting the Committee in questions relating to the framing of new rules or the alteration of old rules for the construction of ships and machinery. The election of the twelve members was to be vested in this Institution, the Institution of Engineers and Shipbuilders in Scotland, and the North-East Coast Institution of Engineers and Shipbuilders. The Council of this Institution have recently proceeded to the election of four representatives, and have selected the following gentlemen, viz., Messrs. H. H. Laird and J. H. Biles as shipbuilders, Messrs. R. Sennett and A. D. Bryce-Douglas as engineers."

The next paragraph refers to the gold medal which the Council has decided to present for the best paper of the year. This matter has already been noticed in these columns, but it now appears that the presentation of a gold medal is to be an annual event, supposing papers of sufficient excellence are forthcoming. The medal will not be presented to members of Council, but is available for ordinary members and associates.

The subject of summer meetings of the Institution has for some time engaged the attention of the Council. The meetings held in 1886, and the two following years, in Liverpool, Newcastle-on-Tyne, and Glasgow, not only proved very successful, but resulted in great advantage to the Institution. The report stated that negotiations were in progress for the holding of a second session during the current year. If circumstances should prevent this meeting taking place in the provinces, arrangements will be made to hold it in London in connection with the Royal Naval Exhibition. The President subsequently stated that it had been determined that the important work of the Institution could not be carried on at one meeting, and it had therefore been decided in future to hold two meetings a year, the second meeting to take place either in London or elsewhere.

PRESIDENT'S ADDRESS.

Lord Ravensworth, in the course of the usual annual address, referred to the loss the Institution has sustained in the death of Mr. William John, whose great abilities as a naval architect were well known to all present. He had, the President reminded his hearers, gained a valuable prize in open competition for the best design of a war vessel for the United States. This ship was named the Texas, and was being built at the Norfolk Navy Yard. Lord Ravensworth also referred to the late Mr. Bernard Waymouth, of Lloyd's, who was a vice-president of the Institution. Some remarks as to the general position of the Institution next followed, Lord Ravensworth having in mind certain strictures which had been made by some anonymous letter writers, and which, it may be stated in passing, have a most remarkable family likeness to each other. The Institution is compared unfavourably with other bodies of a similar nature, the North-East Coast Institution being specially instanced as superior to what may fairly be called the parent Society. It is a curious fact that a few pages further on in the journal in which these letters appear there is a paragraph stating that a paper originally read by Sir Nathaniel Barnaby in 1887, had been re-read at a meeting of the North-East Coast Institution for the purposes of discussion. To read its papers is one of the greatest compliments an Institution of this kind can pay to another. It is a compliment which the Mechanical Section of the British Association has also paid to the Institution of Naval Architects. It does not, however, require such facts as these to refute those who speak of one of our most flourishing and best conducted technical societies in the extravagant terms that have been lately used. Lord Ravensworth next proceeded to deal with the chief items in the programme then before the members. As the papers have now mostly been read, it is not necessary to follow his lordship in his remarks. He also spoke of the recent utterances in Parliament on the question of commerce protection and the proposed whole transfer of our mercantile shipping to a neutral flag in time of war. As might be anticipated from those who know the manfulness with which Lord Ravensworth has always upheld the policy of sea power for this country, both in the Navy and mercantile marine, such theories as have been lately put forward received nothing but condemnation at his hands. He pointed out by cogent reasoning how disastrous it would be if the nation ever built its faith on so poor a thing as the protection of a neutral flag. He also impressed upon his audience the necessity of a Government forming a war programme in time of peace and determining the amount of protection required for the seaborne commerce. It was right that the naval authorities at Whitehall should formulate some definite plan of operations, founded on actual facts, and in that way determine what would be the amount of war shipping required to protect the mercantile marine. If the country were in possession of that knowledge, disaster would be on the people's own head if they did not

MODERN FRENCH ARTILLERY.
No. LXI.

HOTCHKISS QUICK-FIRING GUNS—*continued.*

12-*Centimetre Hotchkiss Rapid-Firing Gun, on Centre Pivot Carriage.*—The largest nature of quick-firing guns made up to the present time by the Hotchkiss Company, is the 12-centimetre (4.72 in.) calibre; there exist two types of this gun, a light pattern 37 calibres long, weighing 4730 lb., and a high power pattern 43 calibres long, of 7300 lb. weight. The bodies of both guns are very similar in design to that of the 3.39-in. gun.

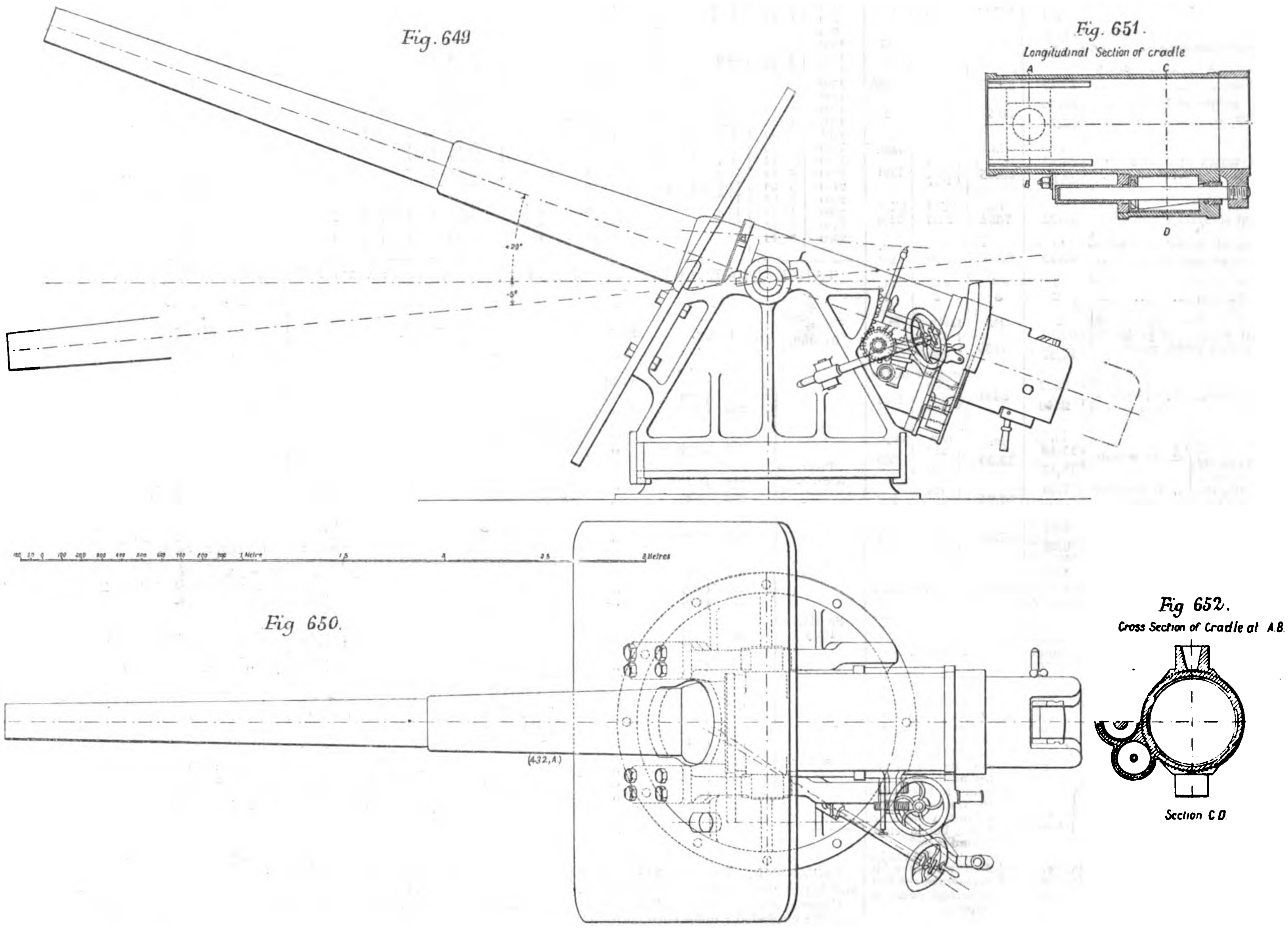
The gun consists of an A tube (see Fig. 653), a jacket which carries the breech action, and a long rifled with an increasing twist terminating at the muzzle with a short portion of uniform angle.

The centre pivot carriage (Figs. 649 and 650) consists of the steel baseplate, which is bolted down to the deck. The pivot, with its side cheeks which form the gun bearings, &c., all in a single steel casting, rests on a live roller ring, and is prevented from overturning by three clamps. The gun itself rests in a gun-metal rocking slide, which forms a mantle around the body. Trunnions are cast in one with the mantle, and so are the spring cylinders and the brake cylinder. This latter has a steel lining. The piston-rod runs through both ends of the cylinder in order to get a constant cubic capacity for the liquid. The gun is exactly balanced in the trunnions and on the pivot, and it can be moved by means of the shoulder-piece in any sense with great ease.

The ammunition is of the usual Hotchkiss type, and five different projectiles are made for this gun, viz.:

Common cast-iron shell.
Steel shell, with large bursting capacity.
Armour-piercing projectiles of chrome steel.
Shrapnel.
Case shot.

For the light gun there are projectiles of two different weights—35.2 lb. and 55 lb. The latter are the same as those for the heavy gun, which only fires the heavy projectile. The metallic cartridge



12-CENTIMETRE 55-POUNDER HOTCHKISS QUICK-FIRING GUN.

hoop which meets the jacket in front; the joint between the jacket and hoop is covered by a locking-ring, which has a shoulder in front corresponding to the shoulder on the hoop; the other end of the locking-ring is bored conical, corresponding to the cone on the jacket. When this locking-ring is shrunk on it prevents any sliding movement of the jacket and hoop, and of the A tube. On the jacket, just behind the locking-ring is a hoop with four longitudinal guides (Figs. 654 and 656) which engage in guides on the carriage, in order to prevent rotation of the gun around its axis on the projectile passing through the rifled bore. No trunnions are made on the gun. Near the breech there is another narrow hoop shrunk on, with a projection underneath the gun, to which are attached, firstly in the centre, the piston-rod of the hydraulic brake, and secondly on each side, the pistons which act to compress the springs for running out the gun after recoil. The breech action is of the ordinary Hotchkiss type, and there are two extractors, one on each side of the wedge. The opening and closing of the breech can be performed by a single man without any undue exertion. Both the light and heavy guns are

The regulating arrangement (see Figs. 651 and 652) for uniform resistance of the brake consists of a bar of equal thickness fixed in the bottom part of the cylinder. The upper surface of this bar is cut to a certain theoretical shape to regulate the flow of liquid during the recoil of the gun. An opening is cut in the rim of the piston to allow for the passage of the regulating bar. The gun is carried forward again after each shot by the action of two coiled springs, which are compressed by the recoil.

The elevating and training gear can be thrown out of action by the gunner who lays the gun, so that the gun can be trained for range and direction either by means of the shoulder-piece or by the gear at the will of the gunner. The sights are not attached to the gun itself but to the rocking slide, as they have to be brought out sufficiently far to the side of the gun for the eye of the gunner who lays it. He stands about level with the end of the breech, but on the left side of the gun, in order to be well out of the way of the men who load. A shield is fitted to the cheeks of the pivot, close to the trunnions, which protects the carriage and the gunners against the projectiles of light artillery.

cases are made on the same plan as for the smaller calibre guns, but if desired solid-drawn cartridge cases are supplied for this gun as well as for the smaller calibre guns; the Hotchkiss type of cartridge case being the more economical, as they only cost about half the price of the solid-drawn cases. To obtain the maximum rapidity of fire the projectile is pressed into the mouth of the cartridge case, and thus forms a complete round of ammunition as for the smaller guns, but it is sometimes preferred to load the projectile and the cartridge apart on account of their weight. Table XCIX. contains particulars of both types of this gun.

BALLISTICAL EFFICIENCY OF HOTCHKISS QUICK-FIRING GUNS.

A very large number of experiments have been made to test the efficiency of the Hotchkiss quick-firing guns; of these many were carried out by the company, and by various foreign governments, but the most important were those made by the French Marine at Gâvre, prior to the adoption of the system. Sufficient data have been obtained in this way, to avoid all necessity of theoretical assump-

Table XCIX.—*Principal Weights and other Data of the Light and Heavy* 12-*Centimetre Guns.*

—	Light, 12-cm.	Heavy, 12-cm.	Light 12-cm.	Heavy 12-cm.
Weight of gun, with breech action	lb. **4750**	lb. **7319**	kilos. 2150	kilos. 3320
Total length of gun	ft. in. **15 2.4**	ft. in. **17 5.4**	mm. 4633	mm. 5345
Length of bore	cal. **37**	cal. **43**	cal. 37	cal. 43
Travel of projectile in bore ..	ft. in. **12 3.6**	ft. in. **14 6**	mm. 3750	mm 4400
Weight of projectile	lb. **36.37** **55.11**	lb. **55.11**	kilos. 16,500 25,000	kilos 25
„ bursting charge for common shell	**5.57** **8.44**	**8.44**	2.53 3.83	3.83
Charge of powder (black pebble)..	**17.19**	**29.76**	7.800	13.500
Total weight of loaded cartridge	**67.46** **86.2**	**99.2**	30.600 39.100	45
Total length of loaded cartridge	in. **36.83** **42.03**	in. **52.55**	mm. 935 1067	mm. 1334
Weight of carriage with shield	lb. **5622**	lb. **7054**	kilos. 2550	kilos. 3200
Height of trunnion centres about the ground	in. **43.30**	in. **43.30**	mm. 1100	mm. 1100
Recoil of gun	cal. **2**	cal. **3**	cal. 2	cal. 3
Initial velocity of projectile (for black pebble powder)..	ft **22.79** **17.87**	ft. **2133**	metres 695 545	m. 650
Muzzle energy of projectile ..	**2603** **2148**	**3481**	m. tons 806 758	m. tns 1078
Thickness of plate perforated by the steel projectile at the muzzle	in. **11.10** **10.19**	in. **13.39**	mm. 282 259	mm. 340
„ „ 1000 metres range	**7.20** **7.91**	**10.31**	183 201	262
„ „ 2000 ditto	**4.87** **6.02**	**7.91**	124 153	201

Table CI.—*Penetration of the Light Hotchkiss* 1-*Pounder Rapid-Firing Gun.*

Kind of Target.	Thickness.	Angle of Target.	Range for complete Penetration.	Remarks.
	in.	deg.		
Steel plates: First class torpedo boat	$\frac{1}{4}$	0	3280	The shell bursts in piercing plates of $\frac{1}{4}$ in. and $\frac{5}{16}$ in., and oak timbers of 4 in. and $11\frac{3}{4}$ in. scattering its fragments behind the target.
		20	3060	
		30	2620	
Steel plates: Unarmoured parts of ironclads	$\frac{5}{16}$	0	550	
		20	440	
		30	275	
Steel plates:	$1\frac{3}{8}$	0	at the muzzle	From 0 to 1100 yards the same shell, fired against a plank of 1 in., bursts close behind it.
.. ..	$\frac{7}{8}$	20		
.. ..	$1\frac{3}{16}$	30		
Oak timbers	4	0	4375	From 0 to 1100 yards, fired on water, it explodes at the first or second point of impact.
		30	4155	
	$11\frac{3}{4}$	0	875	
		30	450	
	18	0		
	$15\frac{3}{4}$	30		

Thickness of oak necessary to stop a shell at the muzzle .. .. $27\frac{1}{2}$ in.
Penetration of shell into oak of greater thickness than $27\frac{1}{2}$ in. .. .. $20\frac{3}{4}$ „

Table CIII.—*Firing Trials of* 1-*Pounder Hotchkiss Quick-Firing Gun in Italy, England, and Germany.*

Italy.

Loaded Chilled Shell.—Range 230 m. (250 yards). Through A and B; exploded in passing through C; 25 holes through D; 18 holes through E; 2 imprints on boiler plate.

Loaded Chilled Shell.—Range 230 m. (250 yards). Through A and B; exploded, 3 holes through C; 3 holes through D; 3 holes through E; 1 slight through crack in boiler plate.

Loaded Common Shell.—Range 230 m. (250 yards). Through A and B; exploded; six holes through C; fifteen holes through D; four holes through E; imprint on boiler plate.

England.

Solid Steel Shot.—Range 275 m. (300 yards). Through all the plates.

Chilled Shell.—Range 275 m. (300 yards). Through A, B, C, D; burst; 24 holes in E.

Common Shell.—Range 275 m. (300 yards). Through A and B; burst; 15 holes in C.

Common Shell.—Range 275 m. (300 yards). Through A and B; burst; 7 holes in C; 8 holes in D; 3 in the side of the boat; 4 in E.

Germany.

Chilled Shell.—Range 300 m. (328 yards). Through A and B; exploded; holes through C, D.

Common Shell.—Range 300 m. (328 yards). Through A and B; exploded; holes through C, D.

Chilled Shell.—Range 300 m. (328 yards). Through A and B; exploded; holes through C, D, and E.

Common Shell.—Range 300 m. (328 yards). Through A and B; exploded; holes through C, D, and E.

TABLE C.—Firing Table for the Light Hotchkiss 1-Pounder Rapid-Firing Gun.

Common Shell.

Distance between sights	33.34 in.
Angle of jump	4 ft.
Charge	2.8 oz.
Mean weight of projectile	1 lb.
Initial velocity	1319 ft sec.

Range.	Inclination.	Drift.	Time of Flight.	Angle of Fall.	Final Velocity.	Marks on Sight-Bar.	Drift Marks.	Mean Deviation. Range.	Mean Deviation. Drift.	Mean Deviation. Height.	Dangerous Space for Target $5\frac{1}{2}$ ft. High	Highest Point of Trajectory.
yards	dg. min.	yards	seconds	deg. min.	ft.	in.	in.	yards	yards	yards	yards	ft.
100	0 06	0.01	0.2	0 11	1234	0.058	0.003	22.3	0.06	0.07	total range	
200	0 17	0.04	0.4	0 24	1161	0.164	0.007	21.3	0.12	0.14		
300	0 29	0.09	0.6	0 38	1091	0.281	0.010	20.5	0.19	0.22	217	
400	0 42	0.16	1.0	0 52	1037	0.406	0.014	19.8	0.25	0.30	150	
500	0 56	0.27	1.3	1 09	987	0.543	0.018	19.1	0.32	0.39	113	14
600	1 10	0.43	1.7	1 28	944	0.679	0.023	18.5	0.42	0.49	90	
700	1 25	0.64	2.0	1 49	906	0.824	0.027	18.0	0.50	0.57	74	
800	1 42	0.87	2.4	2 12	874	0.989	0.032	17.5	0.55	0.65	68	
900	1 59	1.2	2.7	2 37	843	1.154	0.037	17.1	0.63	0.79	53	
1000	2 16	1.6	3.1	3 05	819	1.319	0.042	16.7	0.70	0.90	46	67
1100	2 35	2.0	3.4	3 35	796	1.504	0.054	16.5	0.79	1.02	40	
1200	2 55	2.5	3.8	4 07	775	1.698	0.067	16.3	0.89	1.1	36	
1300	3 16	3.2	4.2	4 42	756	1.902	0.079	16.0	0.99	1.3	32	
1400	3 38	3.9	4.5	5 20	741	2.116	0.092	16.0	1.05	1.4	29	
1500	4 00	4.7	4.9	5 59	726	2.331	0.104	15.9	1.1	1.5	26	184
1600	4 24	5.7	5.4	6 30	711	2.565	0.120	15.9	1.3	1.7		
1700	4 49	6.7	5.8	7 13	695	2.808	0.136	15.9	1.4	1.9		
1800	5 15	7.9	6.2	7 56	682	3.063	0.152	15.9	1.6	2.1		
1900	5 42	9.4	6.7	8 31	670	3.334	0.168	16.1	1.6	2.4		
2000	6 10	11.0	7.1	9 14	659	3.601	0.184	16.5	1.7	2.7	..	387
2100	6 39	12.7	7.6	10 00	650	3.877	0.207	16.9	1.8	3.0		
2200	7 09	14.7	8.0	10 48	641	4.181	0.229	17.2	2.0	3.3		
2300	7 40	16.8	8.5	11 39	632	4.487	0.252	17.6	2.2	3.6		
2400	8 12	19.3	9.0	12 31	623	4.804	0.274	18.1	2.4	4.0		
2500	8 46	22.0	9.5	13 24	613	5.140	0.297	18.7	2.5	4.6	..	701

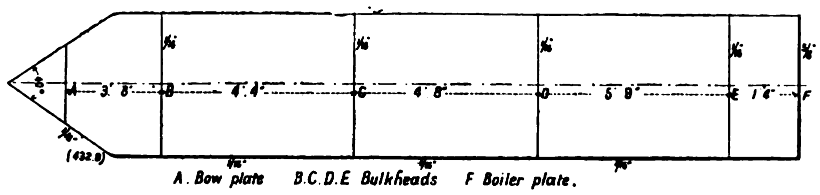
TABLE CII.—Light 1-Pounder Rapid-Firing Gun. Tests against Plates representing Gun Shields and Boiler Plates.

Firing Ground.	Range.	Shell.	Target.	Effect.
	yards m.			
Pola, Austria.	328 (300)	Steel	$1\frac{1}{8}$-in. (25 mm.) steel plate	Partially through.
	218 (200)	„	$\frac{3}{4}$-in. (20 mm.) iron „	Through.
	218 (200)	„	$\frac{3}{4}$-in. (20 mm.) iron plate at 70 deg., in front of $\frac{9}{16}$-in. (15 mm.) iron plate at normal. Distance between plates, 10 ft. (3 m.)	„
	218 (200)	„	$\frac{3}{4}$-in. (20 mm.) iron plate at 50 deg., in front of $\frac{9}{16}$ in. (15 mm.) iron plate at normal. Distance between plates, 10 ft. (3 m.)	Through front plate; broke up on rear one.
	218 (200)	„	$\frac{3}{4}$-in. (20 mm.) iron plate at 30 deg.	Glanced.
	218 (200)	„	$\frac{9}{16}$-in. (15 mm.) iron plate at 30 deg. in front of $\frac{3}{8}$ in. (10 mm.) iron plate at normal. Distance between plates, 7 ft. (2 m.)	Through front plate; head through e one.
	218 (200)	„	$\frac{3}{8}$-in. (10 mm.) iron plate at 30 deg., in front of $\frac{9}{16}$ in. (15 mm.) iron plate at normal. Distance between plates 7 ft. (2 m.)	Through front plate, exploded; pieces through rear one.
Spezia, Italy	218 (200)	Common	$\frac{1}{2}$-in. (12 mm.) steel plate at 45 deg.	Through.
	262 (240)	„	$\frac{5}{16}$-in. (9 „) „ 25 „	Hole through; shell glanced.
	262 (240)	„	$\frac{5}{16}$ „ (9 „) „ in front of $\frac{11}{16}$-in. (18 mm.) iron plate. Distance between plates, 3 ft. (80 cm.)	Through both plates.
	273 (250)	Steel	$\frac{5}{16}$-in. (9 mm.) iron plate rivetted to $1\frac{1}{8}$-in. (25 mm.) iron plate.	Penetrated $1\frac{5}{16}$ in. (34 mm.)
	262 (240)	„	$\frac{3}{4}$-in. (19 mm.) iron plate rivetted to $\frac{13}{16}$-in. (21 mm.) iron plate.	„ $1\frac{1}{2}$ in. (37 mm.)
Portsmouth, England.	300 (274)	„	$\frac{5}{8}$-in. (16 mm.) iron plate at 45 deg.	Through.
	300 (274)	„	$\frac{1}{2}$ „ (13 „) Bessemer steel plate at 60 deg.	„
	300 (274)	„	1 „ (25 „) „ „ normal	Point through.
	300 (274)	„	$\frac{1}{2}$ „ (13 „) „ „ 45 deg.	Through.
	300 (274)	„	Four $\frac{3}{16}$-in. (5 mm.) iron plates, 5 ft. ($1\frac{1}{2}$ m.) apart.	Through two, burst; holes through the third.
	200 (183)	„	$\frac{3}{4}$-in. (19 mm.) steel plate	Point through.
	200 (183)	„	$\frac{1}{4}$ „ (6 „) „ at 30 deg.	Through and burst.
	200 (183)	„	Two $\frac{3}{16}$-in. (5 mm.) steel plates, $6\frac{1}{2}$ ft. (2 m.) apart, and at 25 deg. to the line of fire.	Through first plate, burst, and fragments through second.

tion, and the firing Tables and statistics of penetration given, are the results of actual trials. Taking first the firing Table C. for the 1-pounder (37 millimetres), it may be mentioned that this was computed by the French Naval Department from the Gâvre trials, the Table of Penetration CII. coming from the same source. With reference to the last named Table, it may be mentioned that the target used represented the steel hull of a 100-ft. torpedo boat, and at a range of 200 yards, the steel pierced the sides and bunker plates, and penetrated the boiler. Fired end on against the same target, the projectile passed through the bow and four of the transverse bulkheads.

A very interesting series of trials were carried out in Italy, England, and Germany with this gun, against a target representing a torpedo boat, and of which a diagram is given in the annexed Fig. 657, showing the distance between the bulkheads and the thickness of all the plates. In Table CIII. are

Fig. 657.



A. Bow plate B.C.D.E Bulkheads F Boiler plate.

appended particulars of all these trials, in which the various kinds of projectiles fired with this gun were employed.

In our next articles we shall refer to the ballistical efficiency of the larger calibres.

French Railway Traffic.—The receipts of the six great French railway companies last year showed a falling off of 180,000*l.* in round figures, as compared with 1889. The traffic of that year, having been largely augmented by the Paris Exhibition, was 3,120,000*l.* in excess of the collection for 1888.

MODERN FRENCH ARTILLERY.
No. LXII.
BALLISTICAL EFFICIENCY OF QUICK-FIRING HOTCHKISS GUNS—*concluded.*

As we have already said, before the Hotchkiss artillery, both of the rapid-firing and revolving classes, was adopted as standard weapons in the French army and navy, it followed as a matter of course that a long series of official trials were carried out with both arms. Indeed, these trials extended over a series of years and supplied data of an extensive and incontrovertible character. In addition to these prolonged experiments, others of considerable importance have been carried out in various countries, and in the present article, supplementing what has already been said about the 1-pounders, the results have been summarised, the figures being taken from official sources. Only the ballistical performances of the 3-pounders and 6-pounders are referred to, as best representing the system. Table CIV. is the firing Table compiled for the 3-pounder from tests at Shoeburyness. In the column headed "actual drift" is recorded the deviation of the projectile, first to the right and then after a certain range, to the left. This arises from the permanent compensation for drift made by giving the tangent sight bar an angle of compensation of 1 deg. for the 3-pounder and 2 deg. for the 6-pounder, this giving the best compensation at fighting ranges under 3000 yards.

A number of French official tests were made at Gâvre with the view of ascertaining the penetrating power of the 3-pounder; these were preceded by experiments to determine the reduced charges required to give striking velocities corresponding to different ranges. The following Table gives the mean result of five rounds fired with each charge.

TABLE CV.—*Charges, Striking Velocities, and Corresponding Ranges for 3-Pounder Rapid Firing Gun.*

Powder Charge.	Striking Velocity.	Corresponding Range
oz.	ft.	yards.
3.25	608	5400
4.33	690	4375
5.25	780	3450
7.00	910	2650
17.50	1496	765
18.33	1617	545

The diagrams Figs. 658, 659, and 660 illustrate clearly the results obtained with seventeen rounds fired at oak targets with ranges varying from 5400 yards to 2650 yards, the projectiles being common shell. These rounds were divided into three series, the thickness of the target being 11.8 in., 15.75 in., and 19.5 in. respectively. Figs. 661 to 667 illustrate the results of firing at various targets and in different places with the 3-pounder.

A series of experiments was carried out at Spezia with a 6-pounder that was fired with a range of 109 yards and blind steel shell. Fig. 668 shows an Italian target made of an iron plate 6 in. thick, bolted to an oak backing. Three shots were fired with the same results, namely, a penetration of 6 in. The point did not go through, but the plate was opened with a wide crack. The base of the shell broke off at the face of the plate. The second target consisted of a Creusôt steel plate 4 in. thick (Fig. 669). The shell pierced the plate and went 4 in. into the backing; two rounds were fired with the same result. Fig. 670 shows the target fired at in Madrid—a laminated structure of two 2-in. iron plates secured to a wood backing. The range was 109 yards, and five shots were fired with the results shown in the diagram. At Portsmouth (Fig. 671) a 2-in. steel plate, backed by two 1-in. plates, also of steel, were pierced at a range of 300 yards. At Portsmouth two other targets were also fired at with the following results: At 300 yards a ¼-in. plate 6 ft. in front of a 1-in. plate was fired at with loaded shell, which passed through both plates, exploding at the rear (Fig. 672). At the same range a 2-in. steel plate screwed to one 1 in. in thickness and placed 8 ft. in front of a ⅜-in. steel plate was pierced by loaded steel shell. Table CVII. is the firing Table for the 6-pounder.

Fig. 673 is a diagram showing the penetrating powers of the various calibres at different ranges. The targets were of steel plates unbacked. The speed with which these guns can be usefully fired is a question of almost as great importance as those of accuracy and range. Where speed alone is required, the operations of loading, firing, and extracting the empty cartridge can be repeated from fifteen to twenty times a minute. Of course this figure is considerably modified when the gun has to be laid for the target before each discharge, but it is claimed that good shooting can be made by trained men at the rate of thirteen shots a minute with the 3-pounder and 6-pounder calibres. If, however, the sight bar has to be adjusted between the shots, a further reduction takes place, and the experience that has been obtained points to a rate, under those conditions, of from nine to eleven shots, at ranges varying from 500 to 1700 yards. Such results, however, can only be relied upon under the favourable conditions of trial firing; in actual service it is not likely that anything like this record could be obtained. The circumstances attending an attack which these guns would be called upon to resist would, as a rule, be wholly against accurate firing—suddenness of attack, uncertainty of range, difficulty of sighting at night, and so forth. A great difference also exists between an advancing target and a fixed gun, and a stationary target attacked by an advancing gun. With all conditions favourable in the former case 100 per cent. of hits may be made; in the latter sixteen hits out of seventeen rounds have been recorded. With uncertainty of range, however, a rolling platform, veiling the target by smoke, or a heavy sea, would render all hope of such a record quite fallacious, and in the actual practice of defence against a torpedo boat the percentage of hits is more likely to be a question of good luck than skill.

TABLE CIV.—FIRING TABLE FOR THE HOTCHKISS 3-POUNDER RAPID-FIRING GUN.

Common Shell. — Initial velocity .. .. .. 2002 ft. Angle of jump .. .. .. 0 ,,

Service Charge. — Charge .. .. 1.71 lb. Projectile .. .. 3.3 ,,

Length of line of sight .. .. .. 37.48 in.
Angle of inclination of sight bar .. .. .. 1 deg.

Range.	Angle of Fire.	Angle of Fall.	Sight Marks.	Actual Drift.	Time of Flight.	Remaining Velocity.	Mean Deviation.		
							Range.	Direction.	Height.
yards	deg. min.	deg. min.	in.	yards	seconds	ft.	yards	yards	yards
100	0 10	0 10	.11	Right 0.05	.2	1926	16.2	.02	0.05
200	0 14	0 16	.14	,, 0.11	.4	1857	15.6	.04	0.07
300	0 19	0 21	.19	,, 0.16	.6	1788	15.2	.07	0.09
400	0 23	0 25	.25	,, 0.21	.7	1719	14.8	.10	0.11
500	0 28	0 31	.31	,, 0.26	.9	1650	14.4	.13	0.13
600	0 34	0 38	.37	,, 0.31	1.1	1581	14.0	.16	0.15
700	0 40	0 46	.43	,, 0 35	1.3	1529	13.6	.19	0.18
800	0 46	0 53	.50	,, 0 38	1.5	1473	13.2	.23	0.21
900	0 52	1 3	.57	,, 0.41	1.7	1417	12.8	.27	0.24
1000	0 59	1 13	.64	,, 0.44	1.9	1361	12.4	.32	0.27
1100	1 06	1 23	.72	,, 0.47	2.1	1309	12.1	.38	0.30
1200	1 14	1 35	.80	,, 0.5	2.4	1257	11.8	.44	0.33
1300	1 22	1 47	.88	,, 0.6	2.7	1211	11.6	.50	0.37
1400	1 30	2 0	.97	,, 0 6	2.9	1168	11.4	.56	0.41
1500	1 39	2 14	1.07	,, 0.6	3.1	1129	11.2	.62	0.45
1600	1 48	2 29	1.17	,, 0.5	3.4	1092	11.1	.69	0.49
1700	1 57	2 44	1.27	,, 0.5	3.7	1057	11.0	.78	0.53
1800	2 7	3 0	1.38	,, 0.5	4 0	1033	10.9	.86	0.58
1900	2 17	3 17	1.49	,, 0.5	4.2	1008	10.8	.96	0.63
2000	2 28	3 35	1.60	,, 0.5	4.5	991	10.7	1.06	0.68
2100	2 39	3 54	1.73	,, 0 4	4.8	974	10.6	1.16	0.73
2200	2 50	4 13	1.86	,, 0.4	5 0	955	10.5	1.31	0.79
2300	3 2	4 34	1.99	,, 0.3	5.3	938	10.5	1.42	0.85
2400	3 15	4 56	2.13	,, 0.2	5.6	922	10.5	1.54	0.92
2500	3 28	5 19	2.27	,, 0.1	5.9	908	10.5	1.67	0.99
2600	3 41	5 42	2.41	,, 0.0	6.2	896	10.5	1.81	1.07
2700	3 55	6 07	2.56	Left 0.1	6.5	882	10.5	1.96	1.16
2800	4 9	6 32	2.72	,, 0.2	6.9	869	10.6	2.12	1.26
2900	4 24	6 59	2.88	,, 0.4	7.2	856	10.6	2.29	1.37
3000	4 39	7 26	3.05	,, 0.5	7.9	843	10.7	2.51	1.49
3100	4 55	7 55	3.22	,, 0.6	7.9	833	10.8	2.62	1.62
3200	5 11	8 24	3.40	,, 0.8	8.3	820	10.9	2.84	1.76
3300	5 28	8 55	3.59	,, 1.0	8.6	810	11.1	3.06	1.91
3400	5 45	9 26	3.78	,, 1.2	8.9	800	11.3	3.28	2.07
3500	6 3	9 59	3.97	,, 1.5	9.3	787	11.6	3.61	2.24
3600	6 21	10 33	4.17	,, 1.7	9.7	777	11.9	3.83	2.42
3700	6 40	11 09	4.38	,, 2.1	10.1	768	12.2	4.05	2.62
3800	6 59	11 46	4.59	,, 2.4	10.5	758	12.6	4 37	2.84
3900	7 19	12 25	4.80	,, 2.8	10.8	748	12 9	4.70	3.09
4000	7 40	13 5	5.03	,, 3.1	11 2	738	13.2	4.92	3.37

TABLE CVI.—PERFORMANCES OF 3-POUNDER RAPID-FIRING GUN AGAINST WOODEN AND IRON TARGETS.

No. of Series.	No. of Round.	Thickness of Target.	Range.	Nature of Shell.	Depth of Penetration.	Remarks.
Fig		in.	yards.			
660	1	⅝	5400	Steel, blind	Not through	Angle of target 30 deg.. Size of hole 1.8 in. by 1.7 in. Shell rebouuded 20 ft.
660	2	⅝	4375	,,	Through	Broke up 100 yards to rear of target.
660	3	⅝	2650	Steel, loaded	,,	Burst in passing through plate.
660	4	⅝	2650	,,	,,	,, ,,
661	5	2¾	765	Steel, blind	Not through	Point of shell protruded 2.5 in. from rear of plate
961	6	2¾	765	,,	,, ,,	,, ,, 4.5 ,, ,, ,,
661	7	2¾	545	,,	Through	Great excess of velocity.
662	8	4¾	45	,,	Not through	Penetration 4¾-in. Shell rebounded 16 yards.
662	9	4¾	45	,,	,, ,,	,, 4½ ,, ,, 12 ,,
664	10	2⅜	878	,,	Through	
664	11	2⅜	1050	,,	,,	Shell passed 110 yards to rear.
664	12	2⅜	1200	,,	Not through	Point of shell protruded 2½ in. through plate.
666	13	2⅜	930	,,	Through	Angle of plate 25 deg. from normal.
666	14	2⅜	930	,,	..	Shell broke up on impact.
666	15	2⅜	985	,,	..	,, ,,
666	16	2⅜	1095	,,	..	Point stuck in a plate on impact.
666	17	2⅜	1095	,,	..	,, ,,
665	18	3⅛	437	,,	Through	
665	19	3⅛	492	,,	,,	
665	20	3⅛	655	,,	Not through	
667	21	3⅛	109	,,	Through	Plate at an angle of 25 deg.
667	22	3⅛	260	,,	,,	
667	23	3⅛	325	,,	..	Shell broke up.
667	24	3⅛	325	,,	Through	
667	25	3⅛	380	,,	..	Point through plate.
667	26	Torpedo boat targets	710	Steel, loaded	..	Pierced bow plate, three bulkheads, and struck ground 1100 yards without exploding.
667	27	,, ,,	765	,,	..	Pierced bow plate and exploded, making 21 holes in second, 9 holes in third, 12 holes in fourth, and two holes in fifth bulkhead.
667	28	,, ,,	1860	Steel blind	..	Pierced all plates and struck ground 1100 yards beyond.
667	29	,, ,,	2400	,,	..	Pierced bow and four bulkheads and passed 100 yards beyond.
667	30	,, ,,	2400	,,	..	Pierced bow and all plates except boiler plate.
667	31	,, ,,	1312	,,	..	Pierced bow plate and broke up, sending fragments through four bulkheads.
667	32	,, ,,	2730	,,	..	Did not pierce bow plate.
667	33	,, ,,	1312	Steel loaded	..	Struck stern frame and exploded outside.
667	34	,, ,,	1312	,,	..	Pierced bow plate and exploded, sending fragments through all bulkheads except boiler plate which was cracked.

TABLE CVII.—FIRING TABLE, HOTCHKISS 6-POUNDER RAPID-FIRING GUN.

Common Shell. Initial velocity .. .. .. 1818 ft. Angle of jump 0

Service Charge. Charge .. .. 1 lb. 15½ oz. Projectile .. .. 6 „

Length of line of sight .. .. 37.16 in.
Angle of inclination of sight bar .. .. .. 2 deg.

Range.	Angle of Fire.	Angle of Fall.	Sight Marks.	Actual Drift.	Time of Flight.	Remaining Velocity.	Mean Deviation. Range.	Direction.	Height.
yards.	deg. min.	deg. min.	in.	yards	sec.	ft.	yards	yards	yards
100	0 5	0 5	.054	Right 0.00	0.1	1762	20	0.17	0.04
200	0 10	0 11	.108	„ 0.01	0.3	1708	19	0.17	0.08
300	0 15	0 17	.162	„ 0.02	0.4	1655	19	0.18	0.10
400	0 21	0 24	.227	„ 0.03	0.6	1603	19	0.18	0.13
500	0 27	0 31	.292	„ 0.05	0.8	1552	18	0.18	0.18
600	0 34	0 40	.367	„ 0.07	1.0	1503	18	0.24	0.22
700	0 41	0 49	.443	„ 0 10	1.2	1454	18	0.29	0.25
800	0 48	0 58	.519	„ 0.13	1.4	1407	18	0.29	0.31
900	0 56	1 8	.605	„ 0 16	1.6	1352	18	0.35	0.35
1000	1 4	1 19	.692	„ 0.19	1.9	1319	17	0.35	0.37
1100	1 13	1 31	.789	„ 0.22	2.1	1278	17	0.38	0.44
1200	1 22	1 43	.887	„ 0.25	2.4	1240	17	0.41	0.51
1300	1 31	1 56	.984	„ 0.27	2.7	1203	17	0.47	0.58
1400	1 41	2 11	1.091	„ 0 3	2.9	1168	16	0.53	0.65
1500	1 51	2 27	1.200	„ 0.3	3 2	1136	16	0.59	0.73
1600	2 1	2 44	1.309	„ 0.3	3.5	1105	16	0.65	0.81
1700	2 12	3 2	1.429	„ 0.3	3.8	1078	16	0.71	0.90
1800	2 23	3 21	1.549	„ 0 4	4.1	1050	16	0.77	0.99
1900	2 34	3 41	1.667	„ 0.3	4.4	1030	16	0.83	1.08
2000	2 46	4 1	1.786	„ 0.3	4.7	1012	16	0.89	1.18
2100	2 58	4 23	1.914	„ 0.3	5.0	995	16	0.97	1.29
2200	3 10	4 45	2.046	„ 0.2	5.3	979	16	1.06	1.40
2300	3 23	5 7	2.178	„ 0.2	5 6	964	17	1.15	1.52
2400	3 36	5 31	2.317	„ 0.2	5.9	949	17	1.24	1.64
2500	3 49	5 56	2.438	„ 0.1	6.2	935	17	1.33	1.79
2600	4 2	6 22	2.618	„ 0 0	6.5	921	17	1.42	1.94
2700	4 16	6 47	2.773	Left 0.2	6.8	907	17	1.51	2.06
2800	4 30	7 13	2.924	„ 0.3	7.1	894	18	1.60	2.19
2900	4 44	7 40	3.076	„ 0.5	7.4	881	18	1.69	2.36
3000	4 58	8 7	3.228	„ 0.6	7.8	868	18	1.77	2.54
3100	5 13	8 35	3.396	„ 0.8	8.2	856	18	1.86	2.75
3200	5 28	9 5	3.556	„ 1.1	8.5	844	18	1.95	2.96
3300	5 44	9 37	3.733	„ 1.5	8.9	832	18	2.07	3.16
3400	6 0	10 11	3.908	„ 1.8	9.3	821	18	2.19	3.37
3500	6 17	10 47	4.093	„ 2.2	9.7	810	19	2.31	3.54
3600	6 35	11 26	4.285	„ 2.7	10.1	799	19	2.43	3.72
3700	6 53	12 7	4.487	„ 3.1	10.4	788	19	2.57	4.01
3800	7 12	12 50	4.699	„ 3.7	10.8	777	19	2.72	4.31
3900	7 32	13 34	4.920	„ 4.4	11.2	766	19	2.84	4.61
4000	7 53	14 19	5.152	„ 5.2	11.6	756	19	2.96	4.91

TABLE CVIII.—COMPARATIVE RESULTS OBTAINED WITH BLACK OR BROWN AND SMOKELESS POWDERS, FIRED FROM HOTCHKISS QUICK-FIRING GUNS.

Calibres.		Class of Powder.	Powder Charge.		Igniting Charge.		Weight of Projectile.		Pressure on Breech.		Initial Velocity.	
	in.		kilos.	lb.	gram.	oz.	kilos.	lb.	kls. per sq. cent.	lb. per sq. in.	metres	ft.
10 cent. ..	**3.94**	BN	3.100	**6.82**	10	**.35**	15.00	**33**	2400	**34,135**	675	**2214**
10 „ ..	**3.94**	SP_2	6.00	**14.52**	..	..	15.00	**33**	2450	**34,846**	580	**1771**
76 mill. ..	**2.99**	BN 155	1.80	**3.96**	5	**.18**	6.40	**14.08**	2500	**35,558**	735	**2410**
76 „ ..	**2.99**	SP_1	3.00	**6.6**	..	..	6.40	**14.08**	2300	**32,713**	630	**2066**
65 „ ..	**2.56**	BN 154	.850	**1.87**	5	**.18**	4.00	**8.8**	2530	**35,984**	680	**2230**
65 „ ..	**2.56**	C^2 brown	1.650	**3.63**	..	..	4.00	**8.8**	2500	**35,558**	620	**2033**
57 „ ..	**2.24**	BN 154	.475	**1.05**	5	**.18**	2.720	**5.98**	2600	**36,980**	650	**2232**
57 „ ..	**2.24**	C^2 brown	.930	**2.05**	..	..	2.720	**5.98**	2550	**36,269**	600	**1968**
57 „ ..	**2.24**	C^3	.890	**1.96**	..	..	2.720	**5.98**	2400	**34,135**	560	**1836**
47 „ ..	**1.85**	BN 154	.425	**.94**	5	**.18**	1.50	**3.3**	2480	**35,272**	720	**2361**
47 „ ..	**1.85**	C^2	.780	**1.72**	..	..	1 50	**3.3**	2300	**32,713**	610	**2000**
37 „ ..	**1.46**	BNC	.060	**.132**	1	**.04**	.455	**1.0**	1000	**14,223**	508	**1666**
37 „ ..	**1.46**	RS	.080	**.176**	..	..	.455	**1.0**	1200	**17,068**	435	**1426**

NOTE.—The smokeless powders in this Table are indicated by the sign BN.

All that can be said with certainty is that the guns are capable of delivering a rapid fire with deadly accuracy upon the trial ground, and the same elements of uncertainty, of course, belong to every type of ordnance. In connection with this subject the Hotchkiss Ordnance Company states that "It may seem surprising that with all the claimed superiority of rapid fire, so poor a showing should result as but seven hits for a gun during a torpedo attack. This is, however, 41 per cent. of the aimed shots fired during the time allowed. Very full records exist of the results actually obtained from the revolving cannon, and these results have been examined and fairly averaged, from which it results that in revolving cannon fire, where the maximum speed of fire is easily sixty shots a minute, or three times that of the rapid-firing gun, the ranges varying from 1500 yards to 100 yards, the mean speed of aimed fire is 17.5 shots per minute with 38.2 percentage of hits. The short range being carried out to 300 yards, the speed of fire drops to seventeen shots, and transferring this result to the torpedo attack under consideration, it will be found that eight hits would result as the probable amount from revolving cannon fire." Reasonable as this argument appears, it is nevertheless based on misleading data that would scarcely apply to actual warfare. But it is not against torpedo boats that rapid-firing guns will now find their chief sphere of usefulness. Their range, accuracy, and destructive fire will make them always formidable weapons when directed against vessels of far higher importance than torpedo boats. In Table CVIII. are shown the results obtained with various calibres of Hotchkiss quick-firing guns, and charges of black or brown and smokeless powders.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page 369.*)

IN our last issue we carried our report of the recent meeting of this Institution up to the conclusion of the proceedings of the sitting of Thursday morning, the 19th ult. We now proceed with our account.

LEAKY BOILER TUBES.

There was but one paper set down for reading at the Thursday evening's meeting, this being Mr. Yarrow's contribution on "Boiler Construction Suitable for withstanding the Strain of Forced Draught so far as it affects the Leakage of Boiler Tubes." We have already printed Mr. Yarrow's contribution in full (*vide* page 335 *ante*), and we also referred to it in an article published last week. We may, therefore, at once proceed to deal with the discussion.

Mr. Durston, the Engineer-in-Chief to the Navy, was the first speaker. He said that very great thanks were due to Mr. Yarrow for the paper he had put before the meeting. The labour bestowed upon it must have been very great, and the large amount of information he had deduced from experience gained by his firm, was of great value. The paper applied especially to locomotive boilers for torpedo boats, and the speaker thought he was right in assuming that Mr. Yarrow's experience was limited to the case of torpedo boats carrying one boiler. Every engineer would admit that in working with a single boiler the difficulties were considerably less than with a group, on account of complication attending feeding arrangements in the latter case. The speaker referred to this matter because of Mr. Yarrow's remark that marine engineers were under a cloud; and he, the speaker, thought that some of the difficulties recently experienced had been due to expecting as much from a group as would be expected from a single boiler. Although Mr. Durston agreed very largely with the author's remarks, he did not agree with his conclusions. He believed that all the trouble met with was due to overheating of the tubeplate, and that was brought about by want of proper circulation of the water in contact with the plate, owing to not having space enough between the tubes. It did not matter how the tubes were rolled or how good the workmanship, if the overheating took place, the tubes must leak in spite of all the precautions Mr. Yarrow had pointed out. The speaker agreed that it is a mistake to put a taper roller into a parallel hole, and it was clearly better to have a parallel roller in a parallel hole than a taper one in a taper hole. In the one case there might be a little slacking of the tubeplate without any great disadvantage occurring, but with the taper arrangement, if the tube is pushed through the plate, there is at once a large passage for water. The speaker stated that he had tapered the rollers in the reverse direction to that of the drift; thus insuring the tube fitting a parallel hole. Mr. Durston next proceeded to comment on the author's remarks as to the importance of the rollers passing well through the tubeplate, so as to get a slight shouldering of the tube on the inner side of the firebox tubeplate, and fully indorsed the opinions expressed in the paper. At the same time, Mr. Durston added, that with regard to the smokebox tubeplate, he considered that the rollers should not project beyond the plate itself; because the tubes have only to be rolled sufficiently tight for water tightness; for by these means, the tube, being held well in the firebox tubeplate, would obtain a little freedom of movement through the smokebox tubeplate. The speaker said that the recessed rollers, described in the paper, had been adopted in the dockyards for making fast superheatertubes. They had, however, this disadvantage, that if it were required to take the tube out it must practically be destroyed. With ordinary parallel rollers sufficient shoulder can be secured, and yet there would not be enough to prevent the tube being used again. In a ship recently tried the tubes were rolled with a projection on the rollers on both sides of the tubeplate. On the trial there were two boilers exactly similar. The boiler in which the tubes were rolled in that manner leaked, if anything, more than its sister boiler. Mr. Yarrow had remarked on the holding power of an ordinary tube; but the speaker said if the tubes of the tubeplate are nearly red hot there would be no holding power, and hence he preferred to have stay tubes. Speaking of screwing tubes into tubeplates, the speaker said that in one instance where this plan was adopted, the boilers with the screwed tubes were more leaky than the boilers with their tubes rolled in the ordinary manner. He agreed with Mr. Yarrow that experience had shown that there was no benefit from the use of ferrules. He did not say that they were not useful to support tubes when they were worn. In regard to giving freedom for expansion to the flange of the tubeplate by means of the stays near it, that, the speaker said, could be met by ovalling the holes where the stays were connected between the tubeplate and the shell. The speaker again referred to the question of circulation, quoting the following passage from the paper: "The distance between the tubes should be determined with a view to insure an ample supply of water to the hot surfaces and to avoid the steam being imprisoned between the tubes, especially in the region of the tubeplate, so that the heat should be carried away as soon as it arrival was watched with excitement. The Sirius arrived first and the grandiloquent journalist wrote that "the first curl of her (Sirius') *ascending* smoke *fell* on the eyes of the thousands of anxious spectators." The "bull" would almost justify the conclusion that the writer of this was an emigrant from Ireland. There were but four hours between the two on arrival, so that the Great Western won the race, having started 3 days later. Her voyage was accomplished in about 15 days, the distance covered being 3125 knots, an average of 208 knots per day, or 8.2 per hour, the coal consumed being 655 tons. The highest speed was, it is said, 12.88 knots per hour. The Sirius' voyage took about 17 days, having sailed from Cork she had a shorter distance. Her speed varied from 4 knots 4 fathoms per hour to 7 knots, and in the latter portion of the voyage 8 to 11 knots. On 4 days she depended on sail. The home voyage of the Great Western took 14 days, and the Sirius 16 days. The former steamed at the rate of 213 knots per day—close upon 9 knots an hour, with a consumption of 392 tons of coal. On her second voyage the Great Western took 14 days 16 hours out, and 12 days 14 hours home, beating the mail packets and establishing the desirability of sending the despatches by steam. The Sirius only made one voyage. She was not intended for the Transatlantic service, and subsequently traded to St. Petersburg. Between the two voyages of the Great Western a couple of steamers had left Liverpool for America, the first the Royal William, the second of the name, doing the voyage to New York from the Mersey in 19 days, and home in 14½ days. This vessel consumed 14 cwt. 2 lb. of coal per hour, or 16.8 tons per day. This second Royal William was built by Wilson, was of 700 tons, and had engines by Fawcett of 276 nominal horse-power. She afterwards became one of the early P. and O. steamers and was renamed Oriental. The Liverpool and President followed her out of the Mersey at considerable intervals but in the same year, and the former crossed in 16½ days. She was of 817 tons and 276 horse-power nominal, and had apparatus to insure more complete combustion of coal, resulting in a saving of fuel and in the absence of smoke from her funnels.

The voyages of these several vessels indicated the opening of a new era in the Atlantic trade. The passage by a sailing ship was seldom made in much less than a month, whereas with steamers the time taken was about a fortnight. The Admiralty, who then and for many years afterwards arranged for the transhipment of mails, became impressed with the obvious superiority of steamers over sailing ships, and issued circulars inviting tenders for a steamship mail service. Mr. Samuel Cunard got one of these, and saw his opportunity of working out the solution of that day dream to which we have already referred. In Halifax he was associated with several shipowning companies; and with newly built vessels engaged in the West India trade and in the South Sea whale fishery. He also undertook and worked successfully the Admiralty mail service between Boston, Newfoundland, and Bermuda. But, withal, he could not get the Halifax merchants to support him with sufficient capital to warrant him tendering for the Anglo-American service. He came to London, was introduced by a friend to Mr. Robert Napier, the shipbuilder, and through him got to know Mr. George Burns and Mr. David McIver. The latter, to use the words of Mr. Burns himself, "went dead against the proposal," although ultimately he joined the others. They had built up splendid services between Glasgow, Belfast, and Liverpool, which hold the field to this day. Mr. Burns was the more progressive of the two; but shrewdness equalled and guided his enterprise. It was not long before he began "to see daylight through the scheme," as he himself afterwards said, and he entertained the proposal cordially. Entirely through his instrumentality the requisite capital of 270,000*l*. was subscribed. They succeeded in securing a seven years' contract for a fortnightly mail service between Liverpool, Halifax, and Boston, much to the chagrin of the Great Western Company, the owners of the Great Western steamer, who also had tendered. Then commenced the making of history, so far as records are concerned.

Four new vessels were built for the newly organised Cunard Company, the Britannia, Acadia, Caledonia, and Columbia, all wooden paddle steamers constructed on the Clyde and supplied by Mr. Robert Napier with common side-lever engines. The dimensions of the first-named were 207 ft. long, 34 ft. 4 in. broad, and 22 ft. 6 in. deep, of 1154 tons burden and 740 indicated horse-power. The cylinders were 72 in. diameter, and the stroke 6 ft. 10 in. The paddle-wheels were 28 ft. diameter. The cargo capacity was 225 tons, and 715 cabin passengers could be accommodated. Third-class passengers were not then carried in first-class steamers, and it was not until Mr. Inman started his company that the claims of the emigrants were recognised. Indeed the Inman Line made a special feature of their third-class accommodation, while retaining all the good qualities of the first saloons, &c. The Cunarders marked a distinct step in advance. The tonnage of the early Atlantic steamers was in the proportion of 3 or 4 to 1 of nominal horse-power, and the fastest was probably the Great Western, which had attained a speed of 12¾ knots, with passages of 14 days 16 hours out, and 12 days 14 hours home. The Liverpool was of 2½ tons per nominal horse-power, but she was too narrow and was slow and "cranky." She was, however, subsequently improved. The Cunarders also had 2½ tons per nominal horse-power, but, after all, this is but a poor standard of comparison. The Britannia started on her first voyage from Liverpool on "Celebration Day," July 4, 1840, and arrived at Boston after a voyage of 14 days 8 hours, the average speed being 8½ knots, while the coal consumption was 38 tons per day. The Great Western had an average speed of 8.2 knots, and her coal consumption was practically the same as the Cunard vessel. The Americans immensely appreciated the efforts of Burns and the other founders of the company, and Mr. Cunard when he arrived with the Britannia, received, within 24 hours, 1873 invitations to dinner. The rivalry was between the Cunard and the Great Western; between the Clyde and Bristol with Brunel as designer. The latter, when the Cunarders came out, made a bold move in the Great Britain, which was a wonderful ship for her day. This vessel was a departure on existing Atlantic steamers in respect that she was built of iron and propelled by a screw, and had a balanced rudder. She was also much larger than any of her competitors, and had a double bottom on the cellular principle. She was 322 ft. over all, 51 ft. beam, and 32½ ft. depth of hold, her mean load draught being 16 ft. and the tonnage 2984 tons. She was fitted with two-geared engines of 500 horse-power each. Her main shaft was 28 in. in diameter, with a 10-in. hole bored out, through which a stream of water played to keep it cool. The propeller was about 16 ft. in diameter. The interest excited by this vessel is evidenced by the fact that the Queen and Prince Albert made a visit of inspection through her when the vessel was in the Thames. The first passage took 15 days; giving a mean speed of 9¼ knots, but in subsequent running she reduced the record to between 12 and 13 days. She was stranded on the coast of Ireland, and lay for about a year on the beach at Dundrum Bay. Her powers of resistance supplied weighty arguments in favour of iron as a constructive material. She was floated off, repaired, went on the Australian trade, for about 25 years, and is now a coal hulk at the Falkland Islands. She made 36 trips round the world, sailing in these over 1,000,000 knots, and on her last voyage, about 1876, only took 54 days from Gravesend to Melbourne. Her predecessor, the Great Western, was, after serving on the West Indian trade, broken up at Vauxhall on the Thames.

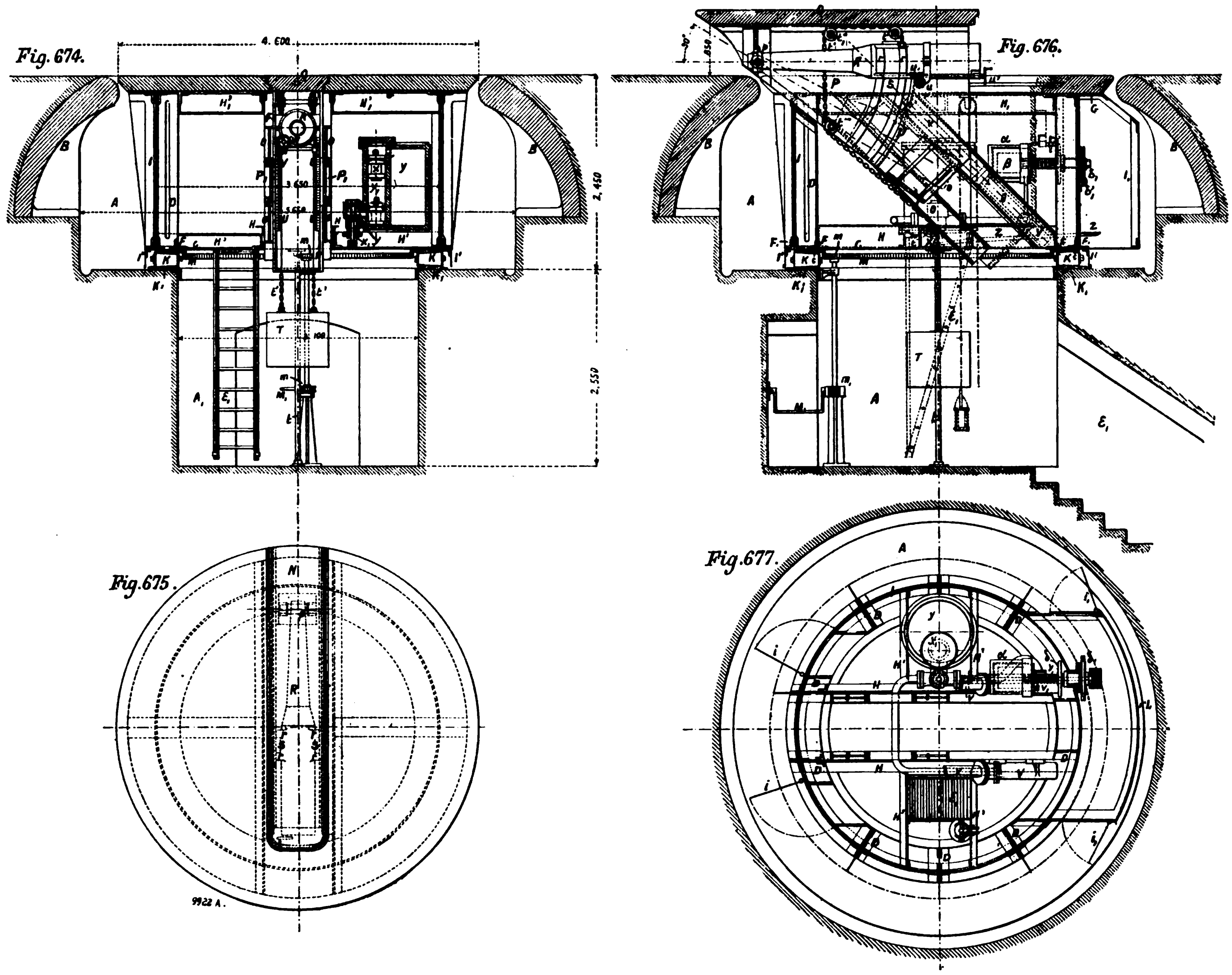
The advent of the Great Britain and her success in speed was met by the Cunard Company with the Hibernia and Cambria. They were built by the well-known firm of Messrs. Steele at Greenock, and again Mr. Robert Napier supplied side-lever engines. These boats differed from the first four in being larger, 220 ft. long, and 1420 tons, and of greater power, 500 horse-power nominal. The passage from Liverpool to Halifax was made in 11 days 21 hours, and home in 10 days 9 hours. The distance, however, to Halifax is approximately a seventh shorter than from Liverpool to New York, so that the Hibernia may be taken as at least equal in speed to the Great Britain, the proportion of power to tonnage being in both cases the same. When the Great Britain came to grief on the coast of Ireland the Cunard Company were masters of the situation, since the Americans had not moved with the times. It is true they had attempted to improve the design of their sailing ships, and it must be admitted that they produced ships with beautiful lines, which, when they got a fair and stiff breeze, beat the steamers, but then Æolus is not always to be depended upon. Even the models of their steamers were subsequently characterised by a fineness of sheer which added materially to their speed. In 1845, they tried the effect of auxiliary engines in sailing ships. Ericsson designed a set of engines for a ship, the Massachusetts (161 ft. by 31 ft. 9 in. by 20 ft.), of 751 tons. In these engines the cylinders worked almost at right angles; the power developed was 170 nominal, and gave the ship a speed in calms of nine statute miles an hour, with a consumption of anthracite coal of 9 tons per day. Steam was generated in two "waggon boilers," and these, it is interesting to note, were fitted with blow engines to raise steam quickly. The propeller was of composite metal and could be raised out of the water when not required. She cost, with engines, 16,000*l*. The average voyage of this ship was 27 days, an improvement of several days, in some cases weeks, over other ships; but since the steamer only took half that time, it was clear to all that America's prestige as shipowners could not be maintained but by powerful steamers. If further stimulus was needed the Cunard Company provided it, for in 1847, the British Government, recognising the extension of commercial relations between the two countries, induced the company to double the mail service, making it weekly. The new contract provided that the steamers should be of not less than 400 horse-power and capable of carrying guns of the largest calibre. They were to leave Liverpool every Saturday (call at Holyhead for mails, if required) for New York and Boston alternately, the Boston steamer touching at Halifax, the New York steamer was to do so also if required by the Admiralty. The mail subsidy was raised from 81,000*l*. to 173,340*l*. per annum. The Cunard Company at once entered into contracts for four new vessels—the America, Niagara, Canada, and Europa, each of 1820 tons, with side-lever engines of 680 horse-power nominal by Napier. The America was noted in her day as being the swiftest on the Atlantic, her fastest voyage from Liverpool to Halifax being done in 8 days 23 hours out and 8 days 10 hours home, about 3 days faster outwards and 2 days homewards than the voyages of the first of the Cunarders eight years previously. The average voyage outwards to America was 10 days 13 hours, and homewards 9 days 15 hours, whereas the Great Western, twelve years previously, took 14 days 16 hours going out and 12 days 14 hours coming home. Shortly before this, however, the Americans, determined to hold their position, started a steamship line to Bremen, Germany, calling at Southampton. Their first steamer, the Washington, by a coincidence left the other side in company with the pioneer of the Cunard Line, the Britannia, and, of course, there was a race. The Washington was undoubtedly a powerful ship, her horse-power was 1 to 2 tons, while in the Britannia it was 1 horse-power to 2¾ tons, but the British vessel won by two days. The English people had not a very high opinion of the American ship, but, as was said at the time, the result of the race probably affected their judgment. It was said that she was "as ugly a specimen of steam shipbuilding" as ever sailed up the Solent. Certainly the Germans received her with every demonstration of welcome at Bremen, the officers being entertained to a banquet by the authorities. The result of the race was not quite satisfactory to the Americans. They had boasted. One of the leading journals said that if Britannia "beats the Washington she will have to run by the deep mines and put in more coals. . . . We shall have in two years' time a system of Atlantic, Gulf, and Pacific steamers in operation that will tell a brilliant story for the enterprise of Brother Jonathan." We fancy the coal bills of the respective steamers would not verify the writer's prediction, and as to the prophecy of brilliant attainments that had best be reserved for our next article.

MODERN FRENCH ARTILLERY.
No. LXIII.

HOTCHKISS AND CREUSOT IRON PROTECTED FORTS.

THE system Creuzé de Latouche for the construction of isolated or combined iron protected forts for the protection of guns, has been adopted by the Hotchkiss Company and MM. Schneider and Co. This system, which is illustrated by Figs. 674 to 682, pp. 422, 423, is of sufficient importance to call for a detailed description. The system provides for

ARMOURED FORT FOR 15-CENTIMETRE GUN.



the installation and protection of guns of various calibres and under different conditions, as follows:

1. Armour-plated pits containing guns or mortars of large or medium calibre, mounted on disappearing carriages.
2. Unprotected forts containing guns on disappearing carriages.
3. Cupolas for mortars.
4. Protected places for rapid-firing guns.
5. Protected moving batteries for guns or mortars.
6. Methods of raising guns by elevators.
7. Coast batteries for quick-firing guns.

The various illustrations show the mode in which it is proposed some of these different systems should be carried out. Figs. 674 to 677 are views of an armour-plated pit in which a gun of large calibre may be mounted. It comprises the pit, containing the gun, mounting, &c., the framework carrying the armour, and the armour itself; the turret and turning mechanism; the elevator; the frame carrying the shutter; and the brake.

The pit A A consists of two cylindrical and concentric chambers A A^1, the upper one being shallower than the lower, and of larger diameter. The walls of this pit are made of béton and the upper portion is surmounted by an iron or steel dome B covered by the earthwork of the glacis as shown. The lower chamber A_1 serves as a projectile magazine, and moreover contains the mechanism for rotating the turret, as well as the counterweight for balancing the gun; in this part of the fort is also placed a reservoir of compressed air for recharging the brake, and supplying leakages in it. The floor of each stage of the pit is surrounded by a gutter from which water collecting can be drained off by any suitable means.

The turret consists of a floor, an iron framework, and an ironclad roof. The floor C is circular and forms the base to which the vertical frames D D are attached by means of double angle irons. These frames support the heavily-armoured roof G. Two horizontal girders H H, and four shorter ones H^1 H^1, complete the framing at the top, and this being duplicated at the floor, makes the whole structure of the turret extremely rigid. The turret is surrounded by a sheet-iron envelope I, in which two openings are made, closed by the doors i; these establish communication with the turret by the gallery A. The part of this envelope near the breech I^1 forms a chamber for working the gun, and to which access is possible by the doors i^1. The floor C is bolted to the steel ring C^1, which rests on the coned rollers K that bear on the ring K^1 bolted to the upper edge of the pit A^1; the distance between the rollers is maintained by means of inner and outer frames through which the spindles of the rollers pass. The turret is caused to revolve by means of a ring M with internal teeth bolted to the floor C and geared with a pinion m driven by an endless screw m^1 and a hand lever M^1 mounted in a recess in the bottom of the pit. So far as is possible it is necessary to prevent the gas or smoke from the gun from entering the lower part of the pit A^1, and this is effected by means of a circular apron of thin sheet iron attached to the outer edge of the floor, and descending to the circular rail K^1, on which the rollers bear. When the doors i^1 are closed the interior of the turret and the working chamber are also protected. An opening N, made in the roof of the turret, gives room for the end of the gun, and the upper part of the side frames of the mounting, to pass. The lifting arrangement, which occupies a central position in the turret, is composed of two parallel iron frames O O, placed at an angle of 45 deg., and strongly braced together, and also to the floor and roof. In the space between these frames is the gun carriage, which slides up and down on the top of the frames upon gun-metal guides; the elevator thus forms a part of the turret and its framing. The gun mounting consists of two vertical side frames P, connected by a plate at the bottom, and carrying at the upper end a horizontal shutter of steel or iron, and of the same thickness as the roof of the turret; this shutter Q is of the form of the opening made in the roof, and spoken of above, and when the gun is lowered it exactly fills the opening. Each of the side frames has a block P^1, with or without rollers, that bears on the slides of the elevator. The gun R is placed between the side frames of the carriage and turns horizontally on a collar p carried by the mounting, and through which the muzzle passes. Two circular projections r r made on the jacket of the gun inclose the guides s, which receive and transmit to the carriage the effort of recoil. A counterweight T, moving up and down the vertical guide t in the chamber a^1, balances the gun, to which it is attached by the chains t t^1 passing over the pulleys t^{11}, mounted on the carriage and the elevator. The gun is trained for elevation by two pinions u u on a horizontal shaft driven by an endless screw, and by two toothed arcs U U fixed to the carriage and gearing with the pinions u u. The rising and falling of the gun and carriage on the elevator is regulated so that in the former position the maximum depression can be given for firing, and in the latter the shutter closing the opening in the roof, falls into position. The brake consists of the two cylinders V V, set at the same angle as the elevator to which they are bolted; the rods of the pistons moving in them bear against the stops X X on the frame. The cylinders are connected by means of pipes with the accumulators, composed of two

FIXED AND TRAVELLING FORTS FOR QUICK-FIRING GUNS.

Fig. 678.

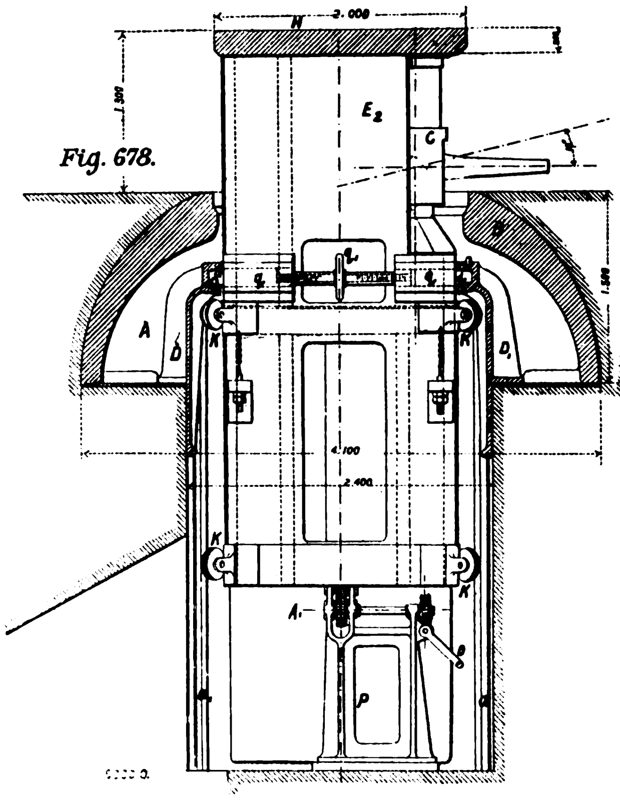


Fig. 679.

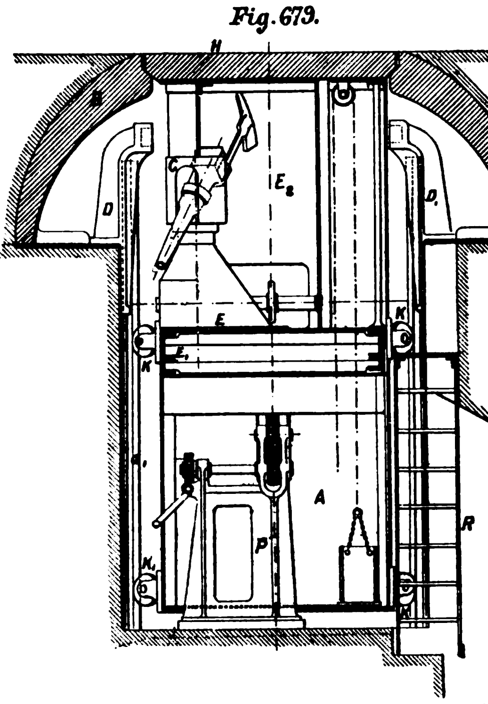


Fig. 680.

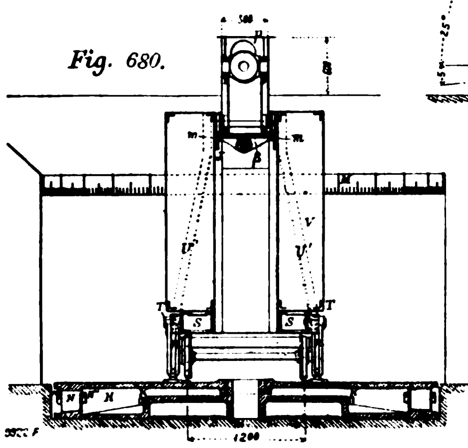
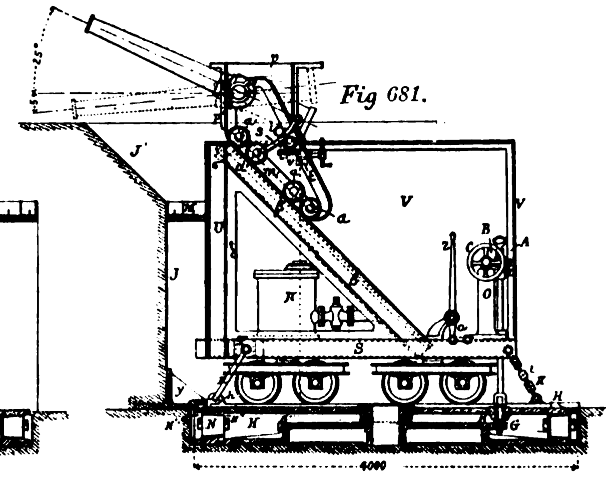


Fig. 681.



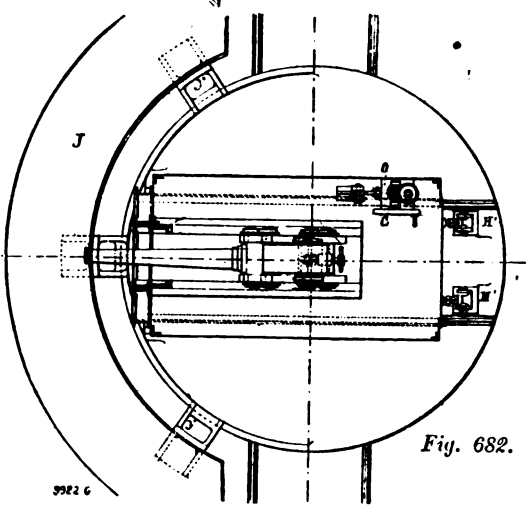


Fig. 682.

cylinders Y Y¹, one of which is placed within the other. In the inner one is a plunger that serves to separate the liquid that enters below, from the compressed air filling the upper part of the smaller cylinder, and the whole of the larger one. The air compressed by the movement of the liquid due to the recoil, is stored up in the accumulator, and when required serves to bring the gun again into firing position. As already stated, losses due to leakage are made good by a compressed air reservoir in the pit. Access to the chamber A^1 is obtained by a gallery and ladder; the projectiles, the weight of which is not intended to exceed 100 lb., are raised to the breech of the gun by a winch; ventilation is secured by opening the shutter in the roof of the turret.

The action of the system is as follows. Assuming the gun to have been fired, the effect of recoil drives the gun and carriage down the slides, and forces the liquid in the pumps V V into the accumulator, sufficient energy being thus stored up to return the gun, by the time it has reached the lowest position, when the shutter Q closes the opening in the roof, and the interior of the turret is protected from hostile fire. The three men in the turret then reload the gun and adjust the vertical and horizontal angles of fire for the next round; the latter training is set by means of a graduated circle on the wall of the pit, and the entire manœuvre is carried out under the orders given from an observing station, and communicated either by telegraph or telephone. The spring valve cutting off the accumulator from the brake cylinders is then opened and the gun is raised into firing position and may be discharged. It cannot, however, be fired until it has reached its maximum elevation, a safety device being introduced to prevent this.

If it is desired to train the gun by direct sighting, one of the men in the turret mounts the ladder attached to the side of the elevator, and after the gun has been raised into firing position, is able to look through the space given by the raised shutter, and to give instructions through a speaking tube, to the man training the gun. The arrangement shown in Figs. 674 to 677 provides for a range of vertical elevation from −5 deg. to +30 deg. The vertical lift of the gun is about 30 in., which might be considerably reduced if a smaller angle of depression were sufficient.

The turret we have described is designed for a gun of 15 centimetres bore, which is necessarily of a short type. The weights of the installation are, approximately, as follows:

Moving Portion.	Tons.
Gun	2.10
Carriage, shutter, chains, &c.	8.33
Counterweight	2.00
Turret, turning mechanism, elevator, accumulator, &c.	50.87
Surrounding armour	70.00
Total weight	133.30

A somewhat similar arrangement of fort is illustrated by Figs. 678 and 679; it is, however, specially adapted for protecting quick-firing guns. The pit, which is made with walls of béton, is in two stages, but instead of the upper and larger one being cylindrical, the iron dome springs from its floor; the form, moreover, is rectangular instead of circular, the angles being rounded. The dome is protected by the covering of earthwork, and the edges of the upper opening into which the roof of the fort fits, are bevelled to the form shown. Iron anchor plates are secured in the walls of the lower pit, and to these are bolted vertical guide rails a^1, the upper ends of which are supported by the brackets D D¹, which rest on the floor of the upper chamber A. The platform E is constructed of a rectangular iron floor framed on a series of girders; the guns mounted on light stands are placed on this platform, which is surrounded by a plate of steel stiffened with angle iron and forming a gun chamber. The inclosure, however, extends only on three sides, as it is unnecessary to protect the fourth or rear side. The front face, which is vertical near the bottom, is inclined inwards above so as to clear the fixed supports. The central portion f^1 is, however, curved outwards. A vertical drum C of steel plate surrounds the pivot of each gun to which it is fixed, and fills the space between f and f^1. Two openings placed opposite each other in the sides of the drum enable the guns to have the necessary range for the maximum angles of elevation, and a vertical shield g placed in the plane of the trunnion axis is intended to stop projectiles that might enter through the front opening in the drum. In the roof of the gun chamber is a shutter H formed of an armour-plate 20 centimetres thick which closes the opening of the front cuirass. The gun chamber E^2 rests on the elevator and is fitted at each angle with two rollers K that take their bearings against the vertical rails a^1 and guide the chamber as it rises and falls. Two vertical racks rivetted to the frame of the chamber are geared to the pinions of the hand-worked elevating gear, and the whole structure is balanced by the two counterweights N which are hung to chains passing over pulleys and attached to the chamber. The open and closed positions of the fort are shown in Figs. 678 and 679. The mechanism for working the gun chamber is also shown. It consists of two pinions O O gearing into the racks L L and driven by a double hand lever O^1, an endless screw and auxiliary pinion serving as intermediate gear. These various parts are carried in an iron frame bolted to the floor of the pit. It is necessary, when the chamber is raised for firing, to secure it in position, and for this purpose four strong bolts Q moving in the guides q are thrown in and out in pairs by turning the handwheel g. The shaft on which this wheel is mounted is hollow, and is cut with reverse screw threads; the screws working in them being secured to the bolts, which slide into the recesses d, made in the heads of the brackets already spoken of as holding the upper ends of the vertical guides. During the ascent and descent of the chamber the guns are depressed as shown in Fig. 679; but as soon as they are free of the dome they can be lifted to any desired angle. Entrance to the fort is gained by an inclined gallery as shown, and the gun chamber is reached by a ladder, the top of which coincides with the lowest position of the chamber. An opening in the floor of the latter gives passage to the ammunition hoist, a chain being attached to it, and passing round a pulley fastened to the roof (see Fig. 679).

The fort illustrated is designed for two quick-firing 57-millimetre guns, and the weights are approximately as follows:

	Tons.
Roof of gun chamber...	9.200
Elevator and gun chamber ...	5.780
Two 57-millimetre quick-firing guns	.470
Two mountings	.650
Counterweights	16.000
Guides, hoisting mechanism, and locking gear	3.400
Armoured dome	45.00
	80.500

Figs. 680 to 682 show the design for an armed truck to carry a quick-firing gun on a disappearing mount. The fixed position for this arrangement is cylindrical as shown in the plan Fig. 681, the top being widened where it cuts the glacis. In the side of this position a graduated metal plate is secured so that the angle to be given may be readily fixed. A turntable H concentric to the position serves as a platform to the truck, which is made to travel on rail tracks for shifting from one position to another; the turntable is mounted on the rollers N, and may be turned either direct by means of levers, or with a toothed crown K, gearing into the pinion G. Locking gear g holds the table in any desired position for firing. The movable portion of the installation consists of a truck mounted on two four-wheeled bogies; it contains the inclined rising path for the guns, the brake accumulator, &c., and it serves as a working chamber. The underframe of the truck is composed of two longitudinal girders and cross-frames; on these is laid the floor of the truck; the sides are made of strong steel plate stiffened with angle iron. The inclined plane is set at an angle of 45 deg., and consists of two girders which serve as a path for the gun carriage. The form of the latter is shown in Fig. 681. It is mounted on eight wheels running on the upper face of the inclined plane. The elevating gear comprises an arc gearing into a pinion worked by a handwheel. The enegy of recoil is stored up in a similar manner to that described for the fort containing the 15-centimetre gun. The various operations for training the gun, anchoring the truck, firing, &c., are evident from the drawing. The following are the weights of this installation, which is for a 95-millimetre gun:

	Tons.
Weight of gun	.700
,, carriage ...	.670
,, inclined plane ...	3.130
,, truck	1.940
,, firing chamber ...	3.060
Total	9.500

VIENNA.—The population of Vienna has increased to the extent of 15½ per cent. during the last ten years.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Concluded from page 397.*)

DETAILS OF MARINE ENGINEERING CONSTRUCTION.

THE last sitting of the meeting was on Friday evening, the 20th ult., and there was a large muster of members and visitors to hear the engineering papers on the agenda. The first paper was the excellent contribution of Mr. Thomas Mudd, of Hartlepool. The other day, in speaking of Mr. Yarrow's paper, we pointed out the great value to engineers of details of good shop practice, and the paper under notice is an excellent example of this. Mr. Mudd, by dint of good thinking and the advantage of practical trial, has introduced various alterations in the boiler engine construction at the important works with which he is connected, and he now liberally put these at the disposal of his brother engineers, who are also his competitors. Happily this is a course of procedure not uncommon among British engineers, or, to widen the circle to its true extent, we will say English-speaking engineers. We print Mr. Mudd's paper in full in our present issue (see page 444), and may therefore at once proceed to the discussion.

The first speaker was Dr. Kirk, who said that doubtless flanging the shell of the boiler instead of the ends was a good plan when the plant was laid out for it. He was glad that the author had taken to welding the flanges, as the lapping of one over the others in the ordinary way required very careful fitting to get a good job on the corner, especially if the corner is at all sharp, and too much dependence had to be placed upon the caulking tool. The speaker had welded the flanges of most of his boilers which he had made during the last twelve years and he found no difficulty in doing it. He though the cost very much the same as in thinning the corners and fitting them in the ordinary way, supposing the job to be properly done. He thought Mr. Mudd was quite right in what he had said about turning crankshafts, the proper way being to turn each shaft complete, as an attempt to turn long crankshafts in three pieces bolted together only leads to bad work. The shafts themselves deflect under their weight, and the truth with which the journals are turned depends on the accuracy of the bearing set up in the lathe. Dr. Kirk's experience agreed with the author's in that he had never found any difficulty in turning the parts separately and bolting them together afterwards. With regard to that part of the paper which referred to piston packing, he agreed with Mr. Mudd that there is an atmosphere of steam behind all packings, and this would amount to about half the working pressure on the piston. Some years before he had made a number of experiments on Ramsbottom rings to see how far they were tight. He bolted two pistons together on one spindle and worked them in an open cylinder. Steam was let into the space between the two pistons, and they were worked by an eccentric on the shop shaft, probably at 120 to 150 revolutions per minute. When one of the pistons was going down, so that it was pressing against the steam between it and the other piston, then it leaked; when it was coming up and the steam following behind it, then it remained tight. They had found pistons remain apparently tight without springs at all. The success of the Ramsbottom packing depended very much on its stiffness and being turned originally a very little larger than the cylinder it has to be put into. It appeared to the speaker that the action which went on was that the ring wears at first and then gets to such a diameter that the steam behind it is just keeping it floating as a tight fit. A point to notice was that when a piston-rod is guided top and bottom it is important to have the ring so that while the piston is free to follow its rod, the ring is free to follow its cylinder. Perhaps the cylinder and the piston-rod, when the cylinder was heated up would not be exactly parallel to each other, and it was good to give the ring a little play. When the piston-rod does not go through the cylinder cover means must be provided for the piston to guide itself, by means of a junk ring or otherwise.

Mr. Fothergill said that he had several sets of Mr. Mudd's engines under his supervision, and also seven boilers constructed in the manner described in the paper, working up to 160 lb. pressure. These had all proved very satisfactory indeed. In order to get the tight fit required for high-pressure boilers the end plate, when flanged to fit the shell, should be turned. The flanging of the shell got over this difficulty. He was pleased to see that Mr. Mudd had taken to annealing the plates. The arrangement described by the author was also of great advantage when it was necessary to keep the boiler low, as it gave greater facilities for repairs. With regard to the piston described by Mr. Mudd, he would only say that he had had several sets of these pistons running for over three years and not a penny had been spent on them.

Mr. Milton said that the paper showed that engineers had at least learned the useful lesson of agreeing to differ. Ninety-nine per cent. at least of the boilermakers of this country do not adopt Mr. Mudd's method of boiler construction, and there were substantial reasons why they should not do so. Undoubtedly the method got over some difficulties, but it raised others. One was that it necessitated the annealing of the shell plates. The ordinary shell plates are now bent cold, and the steel is thus worked into the boiler in exactly the same condition as it comes from the steelmaker, or as nearly so as possible. This annealing must be done with the greatest care, and a careful system of working has to be relied upon in order to insure that the plates are uniformly heated throughout. With big boilers this was very difficult to accomplish, with large plates 14 ft. to 16 ft. long and 5 ft. or 6 ft. wide. The reason Mr. Mudd followed this plan was to get an absolute fit between the plate and the flange, but the speaker's experience of flanging was that no method yet gave an absolutely true surface. In the ordinary flanging of end plates the action of the flanger is that it pushes down the metal so that it is com pressed into occupying a shorter space than it did when it was in the flat. Every time the machine comes down it reduces the pucker, and the speaker had never seen a top flange made on a steel plate with the surface absolutely free from pucker. To get it so, Mr. Fothergill said it would have to be put in a lathe and turned off. In flanging the shells the same thing takes place in trying to make the flange into a plane instead of a cylinder, and the puckers are there when the end plate is drawn on, so that the same action occurs whether the flat end plates are drawn up to the flanged shell plates, or whether the cylindrical plates are drawn up to the cylindrical flange. Mr. Mudd had pointed out the difficulty of making an absolute fit and talked about the "will-o'-the-wisp" method of going round with the caulking iron, but in the boiler itself Mr. Mudd had three of the same kind of seams at the furnaces. There were the end plates flanged and the furnace was made cylindrically to join on to them. One objection, to the speaker's mind, was that in the author's method of making a boiler there was necessarily a much larger water space between the furnaces and the shell than with the ordinary system of making boilers, and therefore the boiler shell had to be made of a larger diameter to contain the heating surface with the same accessibility between the tubes. One of the reasons that had led Mr. Mudd to adopt this method of construction was to get rid of the end caulk, but unless he welded the other end of the shell-plating he had a small point still left, and he did not say he did weld both edges. With regard to the boring of stern-frames and turning shafts, the speaker thought the method the author adopted was a very excellent one and would insure great accuracy when properly carried out, but other methods were being adopted in other shops which gave equally good results. In a firm with which he had been connected they invariably set off the line of shafting by means of sights and battens, and this gave equal accuracy with that described by Mr. Mudd, and there was the additional advantage that by means of the same set of observations they fixed the position of every intermediate bearing in the ship. This had been done with some very high-speed marine engines, but they had never had any difficulty with the running of the shafting. The speaker quite indorsed what Mr. Mudd had said as to the machining of the crankshafts, excepting in one instance. In making the three pieces interchangeable, the author had left out the most difficult problem of all, that was making the bored holes interchangeable. At Hawthorn's they had faced the difficulty, and instead of boring the holes between the flanges, flange against flange, they made in all cases a properly constructed block and bored the holes for the crankshafts from the block and thus made them absoulutely interchangeable. This had been useful when on

DREDGER FOR THE EXCAVATION OF GOLD-BEARING RIVER BEDS, &c.

CONSTRUCTED BY MESSRS. E. F. LACOUR AND THOMAS FIGEE, ENGINEERS, HAARLEM, HOLLAND.

Fig. 3.

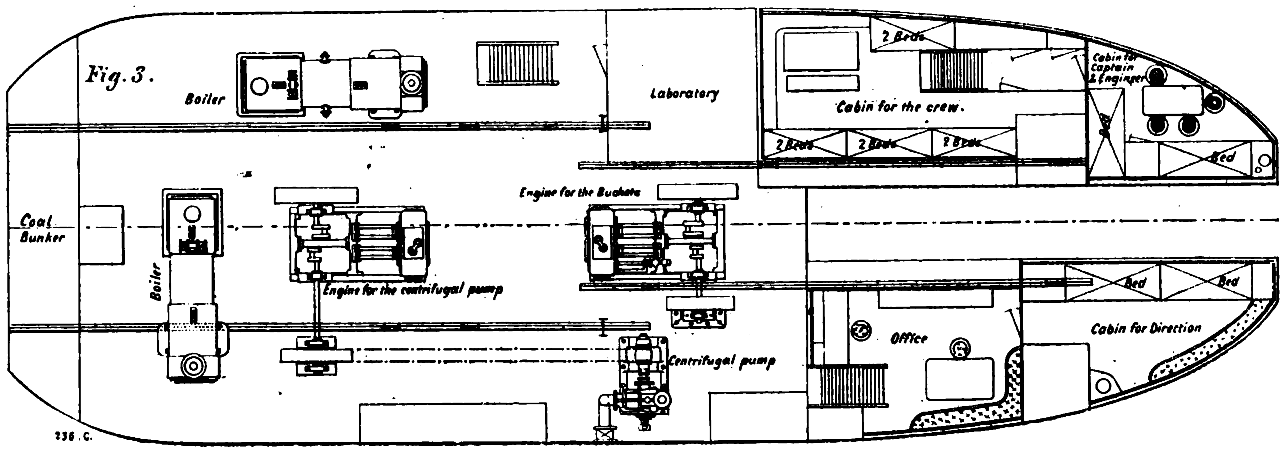


Fig. 4.

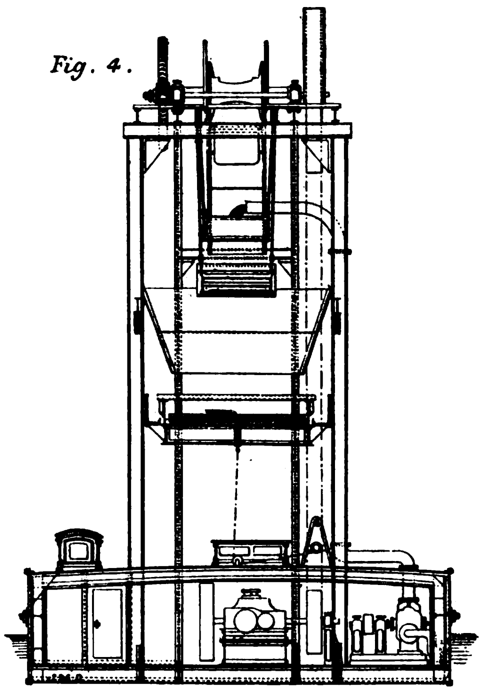
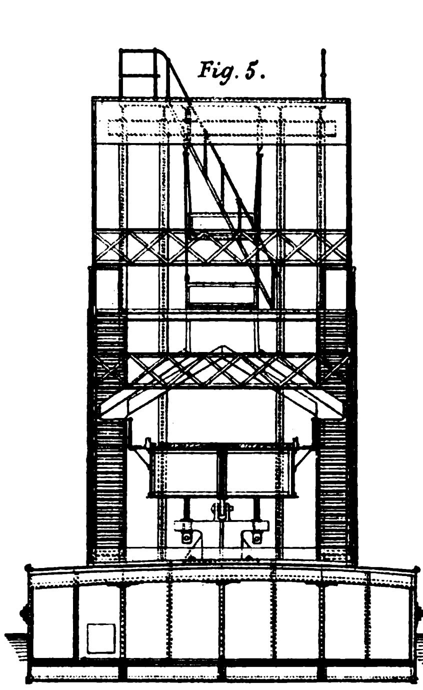


Fig. 5.



We illustrate on the present and opposite pages a dredger, which has been constructed by Messrs. E. F. Lacour and Thomas Figee, of Haarlem, for the excavation of gold-bearing soil in the River Orba, near Alexandria, Piedmont, and which is of interest as a step in the direction of dealing on a large scale, and at low cost, with alluvial deposits containing but a small percentage of gold, and which, therefore, could not be economically treated in the ordinary way. The machine comprises not only a dredger, but also washing plant for concentrating the dredged material, and at once getting rid of the bulk of the débris.

Referring to the longitudinal section and plan, Figs. 1 and 2, and to the two transverse sections, Figs. 4 and 5, it will be seen that the whole plant is mounted on a flat-bottomed barge of shallow draught, which, in addition to affording cabin accommodation for the crew, also contains a laboratory and cabin for the metallurgists in charge. The dredging apparatus is of the ordinary bucket and ladder type, and requires no special description; it is driven by an independent engine, and its arrangement will be at once understood on reference to the views above referred to.

The dredged material is delivered by the buckets on to the screens at B, the frame B, which has a jigging motion imparted to it, containing three screens of different degrees of fineness, placed one above the other. Thus the top screen is a strong one, having meshes 1.6 in. square, which receive the shock of the material falling from the buckets, while the second and third screens have meshes 0.4 in. and 0.16 in. square respectively, the latter screen being of steel wire gauze.

Above the screens is a water-trough A, which receives the water from a centrifugal pump capable of delivering 154,000 gallons per hour and driven by an independent engine. The bottom of the water-trough is perforated all over with holes ½ in. in diameter, and through these the water falls in a shower on to the materials on the screens. By the action of the screens about four-fifths of the dredged material is separated from the rest, and passed on to the inclined pipe E, through which it flows mixed with water to be again deposited in the river bed a sufficient distance in the rear of the dredger. The screens are also provided with a special arrangement which prevents any large pieces of gold from passing off to waste with the lighter débris.

By the arrangements just described about four-fifths of the dredged material are, as we have already stated, at once got rid of, the remaining fifth passes through the finest screen and falls into the hopper C. At the bottom of this hopper is a distributing apparatus, which mixes up the sand and water and causes a steady stream of the mixture to fall through the discharge opening in the bottom on to the sluice D. This sluice is a kind of shallow canal 82 ft. long by 9 ft. 10 in. wide, the bottom being crossed by grooves or flutings, and it is supported by an iron frame at the stern of the vessel, the support being hinged in two directions, so that the level of the sluice can be adjusted either laterally or longitudinally. The former adjustment is necessary to counteract any list or cant which the vessel may have to port or starboard, which cant, if uncorrected, would interfere with the maintenance of a uniform depth of flow over the whole width of the sluice, a uniformity which is essential to its proper working. The lateral adjustment of level is effected by screws, while longitudinally the inclination of the sluice is regulated by a chain led from a winch placed on the deck, as shown in Fig. 1. The sluice can, when required, be inclined so that its inboard end is the lower of the two, as shown by dotted lines; the use of this we shall explain presently.

Referring to Fig. 1, it will be seen that over the upper half of the length of the sluice there extends a shaft; this shaft carries eccentrics which impart motion to a series of distributing rakes, these rakes acting on the mixture of sand and water as it flows over the sluice. The teeth of these rakes also retard the flow of the water, the effect being that the heavy gold settles down in the grooves while the sand passes off with the water over the tail of the sluice. The rakes also, practically covering as they do the upper half of the sluice, serve to protect the deposited gold.

When a sufficient quantity of gold, or gold-bearing sand, has been collected in this way, the dredging is stopped, the sluice altered into the position shown by the dotted lines, the rakes are lifted, and the material deposited in the flutings is raked out and washed down a pipe into the laboratory for subsequent treatment. After working for some five days with a dredger of this class, raising about 1500 tons of stuff per day, it is found that the concentrated gold-bearing material taken off from the sluice into the laboratory amounts to but about 4 cubic yards. Altogether the machine is one which has been well designed to carry out a large part of the work of concentrating alluvial gold-bearing material with a minimum amount of manual labour.

SOME RECENT FAST PADDLE STEAMERS.

The illustration on page 42 represents a type of compound surface-condensing engine designed and constructed by Messrs. Denny, of Dumbarton, for paddle steamers built by their firm. Many of these vessels have attained remarkable results in respect of speed, relative to power developed, consequent not only on the general efficiency of the engine, but also on the exceptionally fine model of the steamers and the design of the paddles. The performances of the Princesse Henriette, Princesse Josephine, Princess Victoria, Duchess of Hamilton, and Clacton Belle have placed Messrs. Denny in a foremost position as builders of paddle steamers. They have always been noted for the production of this type of craft. As early as 1814, the first William Denny built the Trusty, of 88 tons; she was the fifth Clyde steamer, plied for thirty-three years as a steamer, and did other seven years' service as a schooner. In the same year the Marjory, of 38 tons, sailed from Dumbarton and was the first steamer running on the Thames; the Highland Chieftain, built in 1817, and of 85 tons, was the first West Highland trader; while the pioneer steamer in the now extensive service from Glasgow to Belfast, was the Rob Roy, of 87 tons, and subsequently, as the Duc d'Orleans, she inaugurated the Calais and Dover trade. Mr. David Napier, also a Dumbarton man, and a forbear of the famous Napiers, engined this vessel, the horse-power being thirty. The first vessel that traded to the West Indies, too, was built by the Dennys. Dumbarton, therefore, may be said to have helped to nurture the shipbuilding industry, and it is not surprising that it should still occupy a leading position. Our purpose, however, is not to review the past, but to deal with the present and, inferentially, with the future.

In referring to the fast steamers named it may be well in the first place to give the leading details of each vessel, and these we present on the next page, in tabular form, as furnished to us by the firm.

The first two vessels were built for the Belgian Government's mail and passenger service between Dover and Ostend, and the depth of water on the bar at the last-named harbour being limited, the draught of the vessel had to be minimised. The vessels are two-bowed, with a large area rudder inside each stem. The Princess Victoria has been maintaining a fast double daylight service between Larne and Stranraer and the speed and regularity of steaming have suggested the idea of sending some of the mails between Belfast and England by that route. Harbour considerations limited the length of the vessel. This steamer is arranged with a rudder inside the stem to increase manœuvring power. The Duchess of Hamilton trades

DIMENSIONS, &c., OF FAST PADDLE STEAMERS BUILT AND ENGINED BY MESSRS. DENNY, DUMBARTON, N.B.

—	"Princesse Henriette," "Princesse Joséphine."	"Princess Victoria."	"Duchess of Hamilton."	"Clacton Belle."
Ship.				
Length	300 ft.	280 ft.	250 ft.	246 ft.
Breadth	38 "	35 ft. 6 in.	30 "	26 ft. 6 in.
Depth	13 ft. 6 in.	14 ft.	10 ft. 6 in.	10 ft.
Engines.				
Type	Two crank compound diagonal	Two-crank compound diagonal	Two-crank compound diagonal	Two crank compound diagonal
Diameter of cylinders ...	59 in. and 104 in.	51 in. and 90 in.	34½ in. and 60 in.	28 in. and 50 in.
Length of stroke	6 ft.	5 ft. 6 in.	5 ft.	5 ft.
Boilers.				
Type...	Admiralty	Return tube	Admiralty	Admiralty
Number	6	4	3	2
Pressure	120 lb.	115 lb.	115 lb.	115 lb.
Trial.				
When	June 7, 1888	April 19, 1890.	May 28, 1890	May 2, 1890
Where	*Cloch and Cumbrae, four runs	*Cloch and Cumbrae, two runs	*Cloch and Cumbrae two runs	Measured mile two runs
Speed (mean)	21.28 knots	19.77 knots	18 09 knots	17.07 knots

* The distance between the Cloch and Cumbrae Lights, is 13⅜ nautical miles.

between the Ayrshire coast and the Island of Arran in the Frith of Clyde; while the Clacton Belle is engaged on the River Thames between London and Clacton-on-Sea. It is noteworthy that the vessels have connection with four different countries. They are all fitted up in that artistic manner which is characteristic of Messrs. Denny's vessels, and as in our previous general descriptions of these vessels we referred to this feature of their equipment,* we will confine ourselves now to those points of design in hull and engine which mark the vessels out as distinctive from other craft.

We have already adverted to the circumstance that several of the Channel ports require vessels trading to them to be of limited length and light draught, and in such cases a good beam was necessary for stability as well as to admit of those extensive deck saloons now desiderated in passenger steamers. To secure high speed where there was great beam meant additional power, and this again added materially to the coal consumption. Restricted conditions as to dimensions therefore made high speed difficult to obtain; but as a result of a long series of careful experiments in their tank, Messrs. Denny have solved the problem, and have succeeded in fulfilling their guarantees in producing a model to meet the demands as to dimensions and at the same time to so reduce to a minimum the resistance of the hull, as to secure the high speed with a saving of power and of fuel. The proportion of length to beam in paddle steamers has hitherto seldom been less than 8½ of length to 1 of beam; the general proportion one might say is 9 to 1. In the Belgian steamers and the Princess Victoria there is 1 of beam to 7.85 of length, while in the Duchess of Hamilton, a vessel which trades on the Clyde, and in whose case the restrictions as to dimensions were not so stringent, the proportion of length to beam is 8.33 to 1. In the case of the Clacton Belle, on the other hand, the design had to be made so that the vessel could pass under London Bridge, and thus the beam and draught had to be less than might otherwise have been adopted. The proportion of length to beam in her case is 9.3 to 1. It is worth mentioning by way of comparison that the Calais and Dover steamer Empress has 9.3 ft. of length to 1 ft. of beam, the Calais-Douvres 8.9 to 1, the Victoria 8.53 to 1; the Liverpool steamers Princess of Wales and Victoria and the Newhaven and Dieppe steamers Paris and Rouen 8.6 to 1. The Belfast steamer Adder 8.8 to 1. It will therefore be seen that the Messrs. Denny have made a departure from the other leading builders of paddle steamers, and in consideration of the benefits of increased beam in the augmentation of stability, they have rendered a service to marine practice. One or two of the vessels had a difficulty in getting into the largest graving dock on the Clyde, which would indicate that there may be a limit to beam. As regards the proportion of length to depth, it may be said that in the Belgian steamers it is 22.4 to 1, Princess Victoria 20 to 1, Duchess of Hamilton 23.7 to 1, and Clacton Belle 24.6 to 1.

The engines of all the steamers are alike, except, of course, in size. The illustration given on page 42 is from a photograph of the set made for the Princesse Joséphine, taken while they were lying in Messrs. Denny's engine works. They are compactly arranged, the levers for controlling the working are all within arm reach of the engineer, and the whole of the engine may be taken in at a glance from the starting platform. For the power developed the engines are comparatively light, steel, with this end in view, having been adopted wherever practicable. The frames, bedplates, main bearing caps and bushes, pump levers, paddle centres, pistons and cylinder covers are all of cast steel; the shafts, guide columns, paddle arms, brackets and rings, connecting and piston-rods, valve and pump gear, &c., are of forged ingot steel; the condenser shell is of plate steel; and the sea chests, stop and safety valve chests, air pumps, condenser doors, &c., are of brass. The cylinders are placed side by side and work a two-throw crankshaft. The valves are placed diagonally, that on the high-pressure cylinder being of the piston type and the low-pressure valve of the common slide type. This arrangement of valves, in lieu of placing them to the side of the cylinder, greatly economised the thwartship space. It necessitates a special valve gearing, which Mr. Walter Brock, of the engineers' firm, has specially designed.

This valve gearing, clearly shown on our engraving, is a modification of a gear not infrequently to be met with in locomotives on the Continent. Only one eccentric is used, giving motion to a rocking quadrant. What may be called a floating lever is attached at one point to the valve spindle, and at another to the end of a rod from the sliding block in the quadrant. The distance between these two points, taken in conjunction with the length of the lever, and the motion imparted to its end by a rod from the piston rod crosshead, is so proportioned as to give the necessary "lead" to the valve, the total travel being derived from a combination of this motion with that derived from the eccentric.

The boilers are worked under forced draught at the unusually high pressure, for compound engines, of from 115 lb. to 120 lb. to the square inch, the air being supplied by Brotherhood's three-cylinder noiseless fans. The circulating water is supplied by Gwynne's and by Drysdale's centrifugal circulating pumps, the fan cases of which are of brass. The boiler feeding in four of the steamers is done by Weir's independent pumps through their combination check valves, which dispenses with surface and blow-off cocks and pipes, and which are used for circulating the water in the boilers while raising steam. This arrangement further saves weight. Weir's distiller is fitted to all the steamers, except the Duchess of Hamilton, where a Raynor's distiller is in use; Walker's feedheater is fitted to the Clacton Belle.

The results of the speed trials of the vessels are given in the tabular statement, and it only remains to be added that these results have been maintained pretty consistently by the steamers in their regular steaming.

* See ENGINEERING, vol. xlvi., page 146, and vol. l., page 42.

BOILER EXPLOSIONS AT LIVERPOOL, WELLINGTON, AND WEST BUTTERWICK.

THE following particulars of three "formal investigations," recently conducted by order of the Board of Trade, with regard to the cause of boiler explosions at Liverpool, Wellington, and West Butterwick, will no doubt be of interest to our readers. In each case, Mr. Howard Smith, barrister, was the presiding Commissioner, and was assisted by Mr. Wm. C. Laing, consulting engineer, Liverpool, while Mr. K. E. K. Gough represented the Board of Trade.

The first of these investigations was held at Liverpool and occupied two days. The explosion occurred at the iron foundry of Messrs. O. and D. Williams, Taylor-street, on the morning of Tuesday, November 11. The boiler, which was used for driving a mortar mill in connection with the foundry, was of the vertical internally fired class, 7 ft. 6 in. in height, 4 ft. 3 in. in diameter in the shell, and 3 ft. 6 in. in the firebox, made of plates ⅜ in. thick, single-rivetted throughout, and fitted with a safety valve, 2 in. in diameter, loaded by a lever and a Salter's spring balance, supposed to blow off at 45 lb.

When the explosion occurred the firebox was completely collapsed and rent about midway, the crown of the box being also collapsed and torn away all round at its attachment to the uptake. The boiler was shot over several houses to a distance of 70 yards, alighting on the roof of a cottage, where it remained embedded in the party wall between the two rooms. The roof was partially crushed in and a large amount of débris shot into a bedroom in which were a woman and a child; the woman was bruised and sustained a severe shock to the system, while the fireman, who was near the boiler at the time, was also cut and scalded.

The cause of the explosion was excessive pressure, due to the safety valve failing to act owing to the spindle being rusted fast in the bonnet. The spindle was of iron and was a good fit in the hole in the bonnet. It was quite fast, and after the explosion a hammer had to be used to knock it out. The explosion would have been prevented had even ordinary care been exercised.

From Mr. Gough's opening statement it appeared that the boiler was made in 1876 by a local firm, and came into the possession of Messrs. Williams in 1884, at which time one of the owners made a full examination of the boiler and the mortar mill. The working pressure was then 30 lb., and the valve blew at 45 lb. In March last Mr. Williams gave instructions to a man named Draper, an engineer in his employ, to give the boiler a thorough overhauling, which he did, in conjunction with R. H. Roberts, foreman engineer. Mr. Williams examined the boiler himself in May, and found it to be in good order. He relied, however, upon Draper to look after the fittings and general condition. Up to June this year the boiler and mortar mill were used pretty regularly, but since that date they had been lying idle. On the morning of November 11 the engineman lit the fire, and at breakfast time the gauge registered between 20 lb. and 30 lb. At half-past eight he returned, and the boiler shortly afterwards burst with the results narrated.

Mr. O. Williams was the first witness called, and deposed to the purchase of the boiler, its condition, and other matters. He last saw the safety valve blowing off in June at 43 lb. His opinion was that the boiler had been short of water and that this caused the explosion. Everybody knew that a boiler never exploded below the water-line, and as this boiler had burst near the bottom the cause must have been deficiency of water. He produced the blow-out tap, which he stated had been found after the explosion to be slightly open. The water must have been blown away while the attendant was at breakfast. Draper and Roberts were the men who were responsible for looking after the boiler and its fittings.

Mr. David Henry Holman, engineer-surveyor to the Board of Trade, presented a report on his examination of the boiler. He attributed the explosion to excessive pressure, as the safety valve was perfectly fast with rust and dirt, and in the presence of the Commissioners he had it knocked loose with a hammer. The boiler itself he should consider would be quite safe at a pressure of 60 lb., as it was in good condition.

Benjamin Draper, engineer in Messrs. Williams' employ, gave evidence, and said he considered that two other men, Davies and Lee, should have looked after the boiler, as he himself was only there to do repairs or give advice when required. When he examined the valve in March last, it was perfectly free and in good order. From the condition of the boiler he thought the explosion was due to want of water. The valve had always blown off at 45 lb.

Edward Davies, platelayer, who had had charge of the boiler at various times, stated that on the day of the explosion John Levett was in entire charge. Seeing that the boiler had not been used for some time, he warned him to see that all was right. After the explosion Levett said he was sure there was about an inch of water in the gauge glass. Witness did not see a drop of water in the yard after the explosion.

Robert H. Roberts, foreman engineer, thought the explosion was due to want of water.

John Levett, the man who lit the fire on the morning of the explosion, and who still showed signs of the injuries he had received, said the safety valve used to work satisfactorily. The gauge registered about 40 lb. when the boiler burst. The previous day he blew off all the water, and then refilled the boiler half way up the gauge glass. On the morning of the explosion he lit the fire at seven o'clock, and when he went to breakfast at eight o'clock there was no steam showing on the pressure gauge. He left the furnace door open, and when he came back there was a pressure of 30 lb. and the water gauge glass was filled half way up. He then started the engine, but seeing that there was too much water in the mortar mill he stopped it and the explosion occurred. Water was not coming from the blow-off tap before the explosion, nor was steam blowing off at the safety valve. He did not test the valve that morning. He told Lee, the foreman, the previous day that he was going to light the fire, and the reply was "all right."

Robert Lee, the foreman, contradicted the last witness, and stated he had forbidden Levett to use the boiler several days before the explosion.

Hugh Davies, a labourer at the foundry, deposed to hearing steam escaping just prior to the explosion, but could not say where it was coming from.

Mr. James Ramsay, senior engineer surveyor to the Board of Trade, gave evidence to the effect that he had examined the exploded boiler, and found that there was no sign of overheating through shortness of water, and that the explosion was not due to that cause. He referred to the experiments with red-hot furnace crowns, conducted by the Manchester Steam Users' Association, a summary of which appeared in ENGINEERING of October 3 last (*vide* page 400), and stated that those experiments showed that the introduction of cold water on to red-hot plates would not result in the boiler being instantaneously blown up, as Mr. Williams, the owner of the exploded boiler, suggested had been the case. He agreed with Mr. Holman that the cause of the explosion was excessive pressure, on account of the defective condition of the safety valve. He could not say how much pressure would have been required to lift the valve, but it certainly would be more than was necessary to collapse the firebox, which he put down roughly as being worth a maximum pressure of 120 lb. The blow-out tap was found slightly open, but this might have been the effect of the explosion.

At the conclusion of the evidence, Mr. Mulholland, barrister, addressed the Court on behalf of Messrs. O. and D. Williams, and called attention to the fact that the boiler was a good one when purchased, and had been well looked after when in use up to June last. On the day of the explosion the attendant was acting contrary to the orders of his foreman, who had told him not to use the boiler in question, but another. Levett, however, with a view to saving himself a little extra trouble, disobeyed the instruction. He (the learned counsel) disclaimed all responsibility on the part of Messrs. Williams for the carelessness of any man who was really able and competent to fulfil the duties entrusted to him. Every reasonable precaution had been taken by his clients, and he contended that the evidence went to show that there was no such accumulation of pressure as would be necessary to collapse the firebox without overheating.

Mr. Gough having, on behalf of the Board of Trade, briefly replied, Mr. Smith gave judgment. The Commissioners having, he said, seen the boiler for themselves, and heard the evidence, were convinced that the explosion was due to excessive pressure. The boiler generally was in good condition, but the safety valve was inoperative, thus causing the steam to accumulate. The fact that the boiler was blown 70 yards through the air was ample evidence that there was a great pressure of steam. The Commissioners were of opinion that Draper, who was supposed to have oversight of the boiler and its fittings, was to blame for the explosion. They considered that when looking at the fittings in March last he had not examined the safety valve spindle at all, nor had he done so since that time. If, however, he was only engaged to make repairs or give advice, as he stated, and not to look after the mountings except when specifically instructed, there would be that question to consider. Levett, the attendant, was also to blame for neglecting to test the safety valve in order to ascertain that it was in good condition, although he had been cautioned and his attention drawn to the fact that the boiler had been standing idle for some months. Mr. O. Williams himself could not escape blame either for his own default in not telling Draper specially to see to the boiler, or for not seeing that Draper looked after it if he was supposed to do so. The foreman also must have known that Levett was going to work the boiler. Mr. Williams did not appear to have taken all reasonable precautions to see that the boiler was being worked under safe conditions, and he was to blame for that neglect.

On this judgment Mr. Gough applied that part of the costs of the investigation should be paid by Mr. Williams and Draper.

Mr. Mulholland, on being asked if he had anything to say on the question of costs, replied that as the judgment was based upon the utter disbelief of all the witnesses called for Messrs. Williams, he did not see what use there would be in saying anything further.

The Court ordered that Mr. O. Williams should pay the sum of 40*l*. to the Board of Trade.

The second formal investigation was held at Wellington, and related to an explosion which occurred on Monday, November 10, at the works of the Haybridge Iron Company.

The boiler was of the double-flued type, fired by the waste gases from two puddling furnaces, and was made about the year 1876. It measured 18 ft. 4 in. in length, 7 ft. 6 in. in diameter in the shell, and 2 ft. 6 in. in the flue tubes, and was double rivetted at the longitudinal seams, the plates being ½ in. thick in the shell and $\frac{7}{16}$ in. in the tubes. The flue tubes were made of five rings with two plates in each ring, lap-jointed and single-rivetted. The working pressure was 55 lb. on the square inch.

The right-hand flue tube collapsed from end to end, and rent, an opening being formed large enough to allow a volume of steam and hot water to escape which broke the iron pillars supporting the corrugated roof of the works, thereby bringing a portion of it to the ground. One of the men employed at the puddling furnace was killed.

The explosion was simply due to the weakness of the flue tube. The longitudinal seams were nearly in line, breaking joint only 2¼ in. in each case. The tube was not strengthened by flanged seams or other approved means, and was 2½ in. larger in diameter horizontally than vertically. The plates also were somewhat brittle.

Mr. Gough, in his opening statement, dealt with the history and description of the boiler, which from 1885 to 1888 had been insured by the Boiler Insurance and Steam Power Company, Manchester, and had been periodically examined by their inspectors both when working and at rest. In August, 1887, the Insurance Company advised that the boiler should be tested by hydraulic pressure up to 85 lb., as the tube was out of shape, but that recommendation did not appear to have been adopted. In May, 1888, when the policy fell due for renewal, the Insurance Company wrote to the firm, asking whether they proposed to follow the advice given with regard to strengthening the tubes and applying the hydraulic test. In reply the Haybridge Company stated that they did not intend to renew the policy, and that they would not trouble the Insurance Company any further in the matter. In the same month the boiler, along with others at the works, was insured with the Scottish Insurance Company at a cheaper rate. The pressure allowed being 60 lb. A report was sent by this company in December, 1889, to the owners, pointing out certain defects and suggesting that the flue tubes should be put into good order, and that the first two rings would require to be replaced. The Haybridge Company, however, disclaimed having received this report, and no responsible person on the works seemed to know what was the result of the examination or the condition of the boiler. The boiler, however, remained insured all the time.

After Mr. David Watson, engineer-surveyor to the Board of Trade, had presented a report describing the boiler and the cause of the explosion, Mr. Clement Groom, managing director of the Haybridge Iron Company, gave evidence as to their negotiations with the insurance companies. The recommendations which the Steam Power Company made were not carried out, as they (the Haybridge Company) did not consider them necessary, and it was intended to transfer the insurance. They did not tell the Scottish Company of the reports received from the other company with regard to the condition of the boiler, as they wanted a perfectly independent report. Witness thought he had better not say whether the boiler was insured by the Scottish office before it was thoroughly examined, because he could only trust to his memory, and was not certain; he had no knowledge whether it was so or not. It was accepted on May 2, 1888, and the first report of the thorough examination was received on November 12, 1888. That would be six months after the date of the policy. The object of the Haybridge Company in insuring the boiler was "to cover themselves in case of accident" and not for the sake of getting reports, because they considered their own men competent to look after the machinery. "The insurance was effected for the same reason that he would insure his life."

The manager and assistant-manager of the Haybridge Company having given evidence, Mr. J. B. Donaldson, inspector under the Boiler Insurance and Steam Power Company, deposed to examining the exploded boiler on August 2, 1887, and to finding the tube much out of shape. He recommended that it should be strengthened or renewed, and would have preferred a new one. He did not consider the boiler perfectly safe though it was reasonably safe, but the tubes should have been seen to at once.

Mr. J. F. L. Crossland, chief engineer to the Boiler Insurance and Steam Power Company, said that he considered it absolutely necessary that their recommendations should have been carried out. His opinion was that the tube gave way owing to weakness.

After the inspectors and the chief engineer of the Scottish Boiler Insurance Company had deposed to certain points with regard to the inspection of the boiler, Mr. Gough submitted to the Commissioners a list of questions respecting the cause of the explosion and the liability attaching to various individuals.

Mr. Littlewood, solicitor, Wellington, addressed the Court at great length on behalf of the Haybridge Iron Company, pointing out what he considered was a conflict of evidence with regard to the condition of the tubes. The boiler had been insured by the Scottish Company, and was first thoroughly examined six months after acceptance, a course which he might say was not unusual with boiler insurance companies. He submitted that certain reports, said to have been sent to his clients, had not been received by them; that Mr. Groom, as managing director, had done all in his power to secure the safety of the boilers on the works; and that they were attended by men of long practical experience. The explosion, he contended, was one of those occurrences which could not be satisfactorily explained by human intelligence and experience, and which man could not have foreseen or prevented. The whole matter was so shrouded in mystery that it appeared that no blame could be attached to any one.

Mr. Howard Smith then summed up, and delivered a lengthy judgment, pointing out that Mr. Clement Groom, both personally and as representing the Haybridge Iron Company, was to blame for the explosion, inasmuch as he omitted to carry out the recommendations of the Boiler Insurance and Steam Power Company with regard to strengthening the flue tubes and testing by hydraulic pressure. The attendants, in whom Mr. Groom seemed to have so much confidence, were certainly far from capable. The conduct of the Boiler Insurance and Steam Power Company, the Commissioner favourably contrasted with that of the Scottish Company who had accepted the boiler for insurance without a thorough inspection, and at 5s. less premium than the Haybridge Company were paying previously. The coroner's jury had returned a verdict to the effect that the explosion was "Accidental," and this showed the value of a searching investigation by the Board of Trade, without which the facts of this case would not have been brought to light. The Commissioners were convinced that the explosion was no accident, but that it was due to weakness of the flue tube, which could have been easily rectified. The decision of the Court was that the Haybridge Iron Company should pay the sum of 70*l*. to the Board of Trade. The company had been guilty of great negligence, and the costs must be substantial.

The inquiry, which had lasted two days, was then concluded.

The third investigation was held at West Butterwick, near Gainsborough, with regard to an explosion which occurred on Wednesday, November 12, at a corn mill owned by Mr. Richard Coggon.

The boiler was of the single-flued Cornish class, made by Messrs. Horsfield, of Dewsbury, in the year 1858, and measured 20 ft. in length by 5 ft. in diameter, the plates being originally ⅜ in. thick, and the working pressure about 32 lb. The primary rent occurred in the external shell on the right-hand side where resting on the brickwork seating. The boiler was torn into five pieces, one of which was blown 30 yards, falling into the River Trent. The engine-house was wrecked and the attendent killed.

The explosion was caused by the plates, where rupture occurred, being so wasted by external corrosion that they were unable to resist the ordinary working pressure and gave way through sheer weakness. An inspection of the boiler in the external flues by an ordinarily intelligent man could scarcely have failed to reveal its dangerously corroded state, and to have prevented the explosion.

After hearing Mr. Gough's statement respecting the circumstances of the case, and also the evidence of various witnesses, including that of Mr. William Harris, engineer-surveyor to the Board of Trade, Mr. Howard Smith delivered a clear and exhaustive judgment. He pointed out that the boiler was originally properly constructed and of good iron. It was used at irregular intervals, and sometimes not for two or three weeks together, according to the amount of wind, the mill being worked both by steam and wind power. Many years ago some repairs were effected by Messrs. Horsfield, and also by Messrs. Marshall, Sons, and Co., of Gainsborough. In May, 1887, Mr. Coggon reported to Messrs. Horsfield that the boiler leaked and that he wished it repaired, and Mr. Coggon had told the Commissioners that he thought this was sufficient to insure an examination being made of the boiler. A boilermaker named Ellis was therefore sent from Dewsbury, and he went into the furnace tube, which he found corroded, and took particulars of the repairs necessary at that part. Some new plates were subsequently applied and the leakage ceased. As Ellis went into the boiler and tapped it with a hammer Mr. Coggon stated he thought he was making a thorough examination, but Ellis denied tapping it from the inside of the shell, and it was clear that no such examination had been made. The Commissioners did not think Mr. Coggon intended to deceive them, but he was under a misapprehension. These were the last repairs that had been made up to the day of the explosion. Neither Mr. Horsfield nor the boilermaker, Ellis, appeared to be to blame. They went to the boiler in 1887 to stop some leakages and were not requested to make an examination. If a thorough examination had been made the boiler would have been found to be thoroughly worn out. Mr. Smith expressed satisfaction at the manner in which Mr. Coggon and his sons had given their evidence; they seemed to have no desire to keep anything back. The boiler was thirty-two years old and had never been inspected by any one since the day of its birth. It should have been taken off its bed and thoroughly examined in 1887, when the repairs were made to the furnace, as already stated. Mr. Coggon's solicitor had pleaded his cause before the Court, and stated that his client had erred from ignorance and only from ignorance. This was a right description of his behaviour, but it was most gross and lamentable ignorance. The Commissioners were told, Mr. Smith said, that there were other boilers in the locality that were treated in the same way and never examined at all. Mr. Coggon seemed to have come to the conclusion that as long as the boiler did not leak, and as long as it could generate steam, it was perfectly safe, and that, the Court was given to understand, was the opinion of people who had boilers in the district. If that was so, it was a most lamentable state of things. The Commissioners had, Mr. Smith said, already pointed out, *ad nauseum*, the necessity of frequent inspection. They had no hesitation in coming to the conclusion that Mr. Coggon was to blame on account of his gross ignorance. If he was personally ignorant of the working power and condition of his boiler he ought to have employed a competent man to look after it. Having such an instrument in his possession, and which might be a source of danger, it was his duty to ascertain its qualities and properties, Mr. Smith added that he trusted that this investigation, and the remarks he was making, would have some effect. If an explosion occurred again in that neighbourhood, and it could be shown that the owner had had notice of the dangerous state of the boiler, the Commissioners would feel it their duty, should loss of life be occasioned, to call the attention of the Public Prosecutor to the fact, in order that a prosecution for manslaughter might be instituted. They did not propose to take that step in the present instance, as the explosion had resulted through ignorance, gross though it might be.

On this judgment, Mr. Gough applied for costs against Mr. Coggon.

Mr. Taylor, solicitor, offered on behalf of Mr. Coggon, to allow the widow of the deceased engineman a house free of rent and 10s. a week for three years. This, the presiding Commissioner said, would induce the Court to considerably modify its decision regarding costs. On the understanding that Mr. Coggon adopted the course just named by his advocate, the Court would only order him to pay the sum of 10*l*. to the Board of Trade. This, Mr. Smith said, was the lowest order that he had made in the case of any of these investigations.

Mr. Gough then said he proposed to make known to the Court the verdict of the jury, which was as follows: "That the engineman was killed by the explosion of the boiler," and they also found that "there was blamable negligence on the part of Richard Coggon, connected with the state and condition of the boiler." The jurors also found that "there should be some provision by the legislature for the regular testing of steam boilers used in mills and factories, or elsewhere."

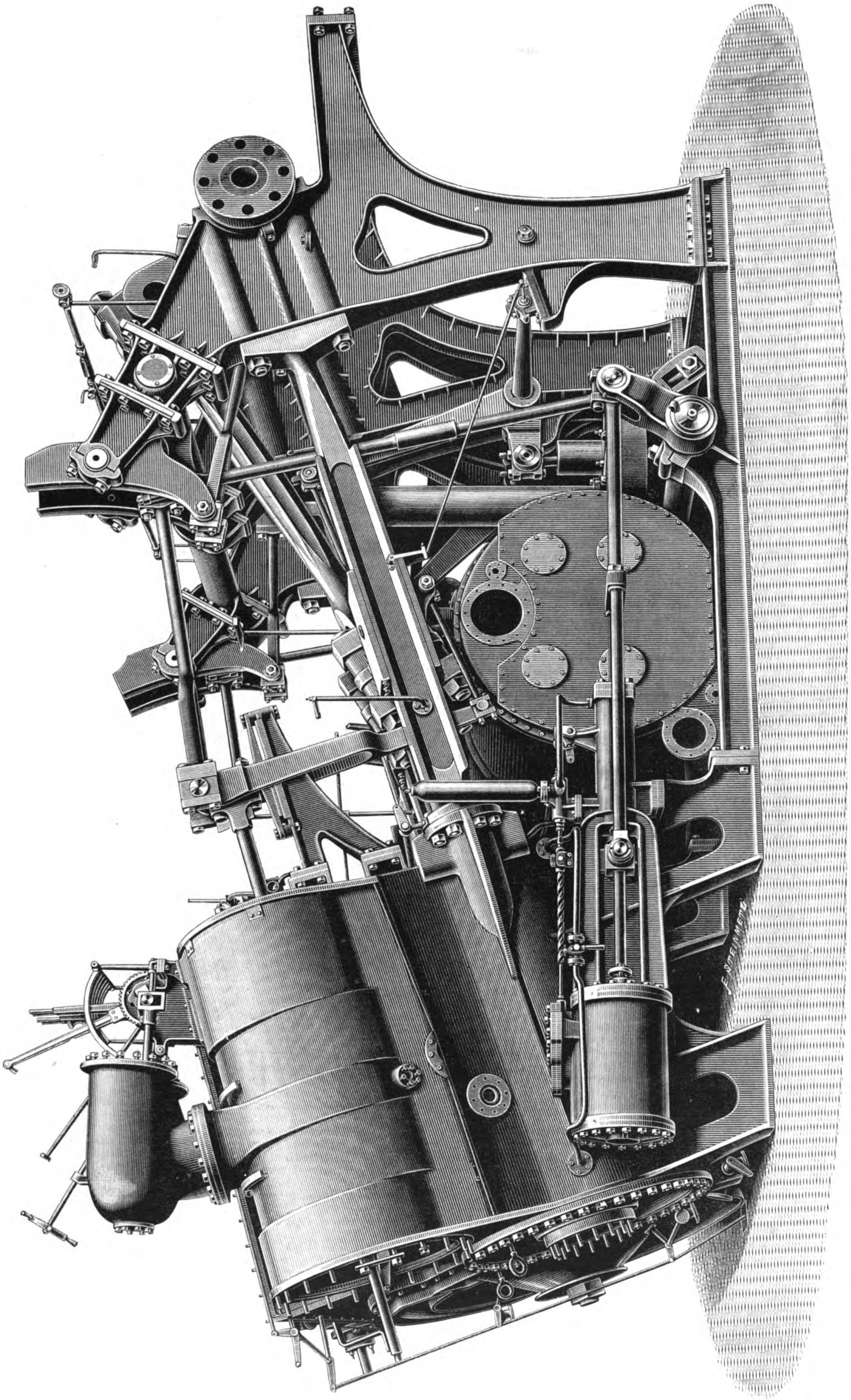
The investigation was then closed.

AUSTRIAN SMALL ARMS.—The Austrian Arms Manufacturing Company has declared a dividend of 3*l*. 10s. per 10*l*. share for 1889-90. In the course of its last financial year the company received orders for 760,631 repeating rifles, of which 469,070 were delivered, leaving 269,554 to be delivered in the course of 1890-1. Other large orders have also been received by the company, so that its works will be fully employed during the whole of 1890-1. The company is now turning out from 8000 to 11,000 rifles weekly.

COMPOUND ENGINES OF THE PADDLE STEAMERS "PRINCESSE HENRIETTE" AND "PRINCESSE JOSEPHINE."

CONSTRUCTED BY MESSRS. DENNY AND CO., ENGINEERS, DUMBARTON.

(*For Description, see Page* 39.)



to replace his famous crack, the Irex. Her chief antagonist was the Thistle (designed by Mr. G. L. Watson), of America Cup fame; and, although the latter did best at first, and headed the prize list at the end, the new boat scored some very telling successes when there was wind enough to suit her, and after some alterations had been made, the chief being the removal of her unnecessary centre-board.

In looking through the list of winners we find Mr. G. L. Watson to be by far the most successful designer, both in large and small craft; the names of W. Fife, A. E. Payne, A. Richardson, and others appear on the list, amongst them the author; but Mr. Kemp is better known as a designer of cruisers and large steam yachts, than in connection with racing craft.

The third section of the work is devoted to a "General Review," and consists of a number of short articles and notes upon questions of interest that have arisen during the past season. The majority, possibly the whole, of these notes have already appeared in the columns of the *Field*; indeed it is only the fact that the work is mostly reprinted from that journal which allows it to be produced at the price at which it is published. A few pages are devoted to "Cruising"—the least satisfactory part of the book—and launches and trial trips. "Fittings and Equipments" is quite good enough to make one want more; the "Obituary" is happily but a small section, although it is sad to be reminded that some good men have been prematurely cut off. A good index completes the book.

BOOKS RECEIVED.

Electric Light Installations and the Management of Accumulators. By SIR DAVID SALOMONS, Bart., M.A., Assoc. Inst. C.E. Sixth Edition, revised and enlarged, with numerous Illustrations. London: Whittaker and Co.

Electric Transmission of Energy and its Transformation, Subdivision, and Distribution. By GISBERT KAPP, C.E. With 130 Illustrations. Third Edition, revised. London: Whittaker and Co.

The Patentee's Guide. By H. F. BOUGHTON, M. I. Mech. E. London: Simpkin, Marshall, Hamilton, Kent, and Co., Limited.

Victorian Year-Book for 1889-90. By HENRY HEYLYN HAYTER, C.M.G. In Two Volumes. Vol. I. Melbourne: Government Printing Office. London: Trübner and Co.

The Comprehensive International Wire Table. Compiled by WILFRID S. BOULT, Assoc. M. Inst. C.E. Liverpool: 60, Castle-street.

A Souvenir. The Visits of the Iron and Steel Institutes of Great Britain and Germany to America. Sketches and Incidents of Journey by "MORIEN," Special Commissioner of the *Western Mail*, Cardiff. Cardiff: Daniel Owen and Co. [Price 1s.]

Maximum Stresses under Concentrated Loads, treated Graphically. By HENRY T. EDDY, C.E., Ph. D. Illustrated by Twenty-five Figures in Text and One Folding Plate. New York: D. Van Nostrand Company. London: Kegan Paul, Trench, Trübner, and Co.

Sell's Dictionary of the World's Press and Advertiser's Reference Book for 1891. By HENRY SELL. London: Sell's Advertising Agency, Limited.

The Stock Exchange Year Book for 1891. By THOMAS SKINNER. Seventeenth Year of Publication. London: 1, Royal Exchange-buildings. [Price 15s.]

The Elementary Part of a Treatise on the Dynamics of a System of Rigid Bodies. Being Part I. of a Treatise on the Whole Subject. With numerous Examples. By EDWARD JOHN ROUTH, Sc.D., LL.D., F.R.S. Fifth Edition, revised and enlarged. London and New York: Macmillan end Co.

A Pocket-Book of Electrical Rules and Tables for the Use of Electricians and Engineers. By JOHN MUNRO, C.E., and ANDREW JAMIESON, M. Inst. C.E., F.R.S.E. Seventh Edition, revised and enlarged. London: Charles Griffin and Co.

Optical Projection; a Treatise on the Use of the Lantern in Exhibition and Scientific Demonstration. By LEWIS WRIGHT. With 232 Illustrations. London and New York: Longmans, Green, and Co. [Price 6s.]

Technisch-Chemisches Jahrbuch 1889-90. Herausgegeben von DR. RUDOLF BIEDERMANN. Zwölfter Jahrgung. Mit 300 in dem Text gedruckten Illustrationen. Berlin: Charles Heymans.

Electricity in Every-Day Life. By FRANK R. LEA, B.A., Assoc. Inst. C.E. London: E. W. Allen.

MODERN FRENCH ARTILLERY.
No. LII.
HOTCHKISS MACHINE AND QUICK-FIRING GUNS.

BEFORE the sudden outbreak of the Franco-German War the world had heard much talk of a mysterious and deadly weapon capable of pouring a fatal hail of shot into any advancing troops, and by means of which the attacking power of a body of infantry provided with such an arm, would be indefinitely increased. The mitrailleuse was to decide the fate of future campaigns, and especially of the great adventure into which France had precipitated herself. A very brief experience falsified these high anticipations, and the mitrailleuse proved itself but a very broken reed. Some years before, at the Paris Exhibition of 1867, the Gatling gun had been exhibited for the first time in Europe; it was the original outcome of the crude attempts which, during the American War, formed the first efforts towards the construction of machine guns. The Gatling exhibit naturally attracted great interest in France, and probably suggested the mitrailleuse. With the termination of the Franco-German War the latter disappeared, but the Gatling gun has, with various developments, held its place and proved its usefulness as a weapon for discharging large quantities of bullets within a given range. But it was clear, especially after the development of torpedo boat attack, that something more than a hail of bullets was necessary, and hence arose the three great types of shell-throwing machine guns—the Nordenfelt, the Hotchkiss, and the Gardner. It is with the second of these that we have now to do, forming as it does so important a part of the land and naval auxiliary armament of France. Designed by an American, Mr. B. B. Hotchkiss, who was employed during the Franco-German War in the manufacture of cartridges for small arms, it speedily was developed into a very complete and efficient weapon. Possibly the decision of the St. Petersburg Congress, which prohibited the use of shell in warfare weighing less than 14 oz., contributed towards the more rapid development of the Hotchkiss machine gun, as projectiles weighing 16 oz. were decided upon as the basis on which the gun was to be designed. From small beginnings the manufacture of these revolving cannon grew in importance, until in 1878 the Hotchkiss factory at St. Denis was of very large proportions; with the death of the inventor, a few years since, the business was turned into a limited liability company.

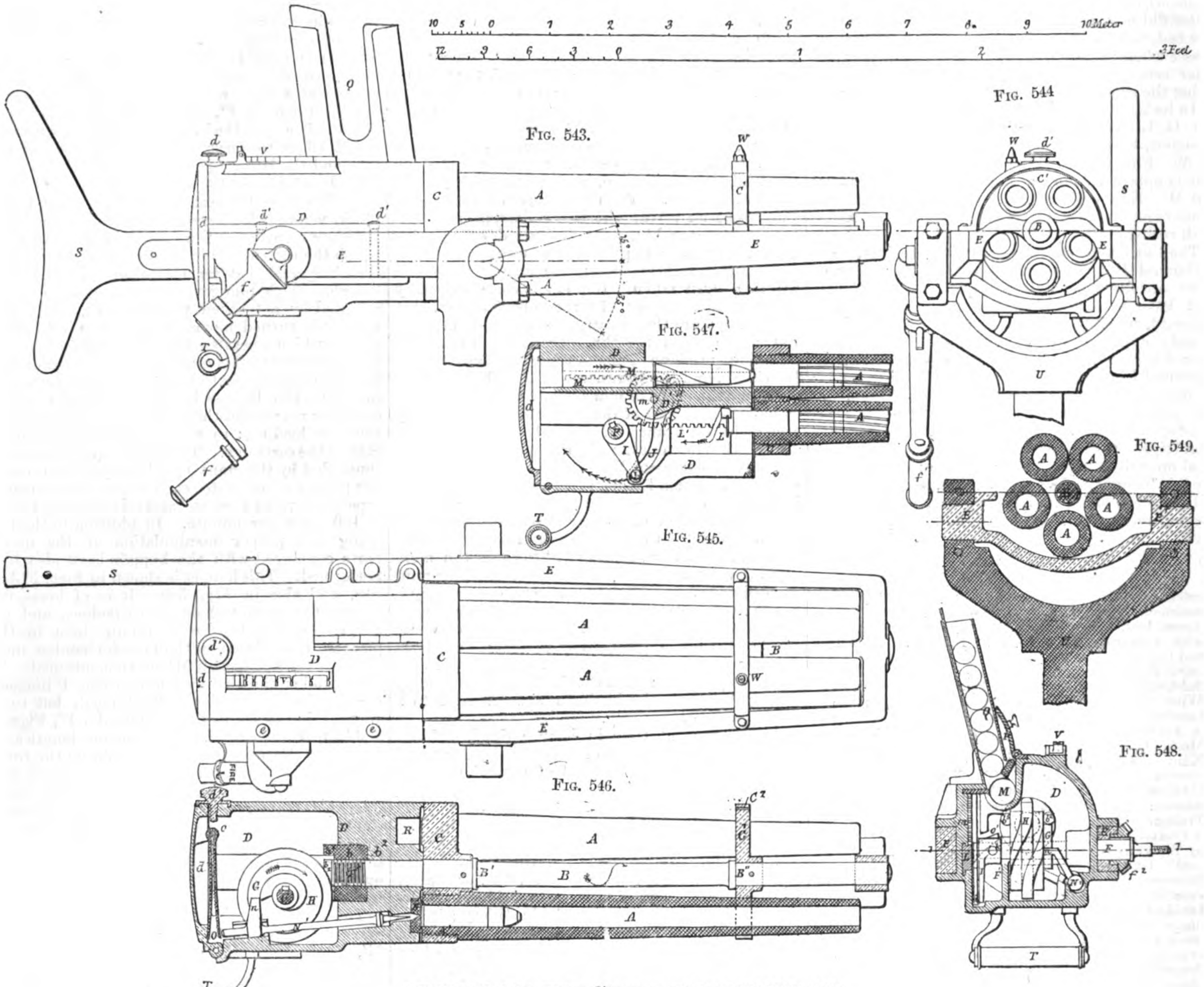
At the present time in France the Hotchkiss revolving guns are made of two classes, for naval and for military service, and of several calibres. Of the former the 37-millimetre (1.45-in.) gun is especially designed for defence against torpedo boat attack, and for taking the offensive in boat or brigade work, or against open deck batteries. The 47-millimetre (1.85-in.) and the 53-millimetre (2.1-in.) are intended for similar, but, of course, heavier work. The 37-millimetre field gun is designed as an auxiliary arm to field artillery; it can be used either for intermittent or continuous firing, and is, therefore, adapted to form a part of an ordinary battery. The 40-millimetre (1.57-in.) flank defence gun for fortification and trench defence, is for a special purpose, and will be described separately. As the mechanism and general construction of this gun is similar in all the calibres, we may take as a type the 37-millimetre for description and illustration.

There are five barrels A A, Figs. 543 to 549, made of Whitworth steel, grouped around a central steel shaft B, and held in position by two brass mountings C; the barrels pass through the forward, and are screwed into the rear disc, and both of these are bolted to the central shaft B; a steel frame E surrounds the group of barrels and forms a bearing for the outward end of the shaft B. The breech-block D, which is fixed to the frame, is made in one casting, the front of which is solid except for certain passages to be presently described, while the rear is chambered out to receive the actuating mechanism; the rear of the breech is closed by a bronze door *d* hinged at the bottom and secured at the top by a locking screw *d'*. Flanges are cast on each side of the breech-block by which it is bolted to the frame. The form of the breech chamber is illustrated by Figs. 546, 547, and 548. In transverse section it is approximately Ω-shaped; the front end is shown in Fig. 546, which indicates the projection and recesses in the chamber; B is the centre shaft; N is a circular seating filled with a hardened steel disc perforated with a small hole in the centre; it is against this disc that the base of the cartridge cone abuts in firing position; the relative positions of the firing pin, &c., are shown at N', Fig. 546; R is an inclined plane dying gradually into the surface of the block; it serves to force the cartridge into the chamber of the firing barrel after it has been partly pushed home by the plunger M, Figs. 547 and 548. Two large openings are made in the block (see Fig. 547), one at the top for feeding in the cartridges, the other at the bottom for ejecting empty cases. In Figs. 546 and 548 is shown the inclined passage in which the firing pin N' is guided. It will be seen that outside on the right hand is a projecting bearing for the spindle F, Figs. 543 and 548, which is also provided with another bearing on the frame and a third within the breech-block on the left-hand side at F'. On the left hand is a recess in the side and at the bottom, the former with dovetailed edges to serve as guides for the extractor rack and the latter to give room for the extractor links I and J. At the top on the left-hand corner, extending from the rear to the front of the breech-block, where it is intersected by the inclined plane R before mentioned, is a semi-cylindrical trough in which the cartridge is fed and is pushed forward by the plunger M that travels in an extension of this trough. This plunger is connected to a rack actuated by a toothed wheel *m*, Fig. 547, which when it is turned moves a similar rack L' underneath, which operates the extractor mechanism. The functions of this mechanism are as follows: To push the cartridge into the five barrels successively; to rotate the barrels in such a way that in each complete revolution there shall be a pause to allow time for loading; to actuate the striker; and to extract the cartridge. These four operations are all controlled by the crank *f'*; they must bear exactly the proper relation to each other, and must be capable of repetition at intervals varying from 10 to 150 times per minute. In addition to the foregoing the proper manipulation of the moving parts connected with the hopper have also to be performed. This hopper is shown in Figs. 543 and 548, and also in Fig. 549. It is of brass, deep enough to receive five or six cartridges, and with the edges turned over to retain them in their places. It is placed on the breech chamber immediately over the trough M before mentioned. The lower end is shielded by a brass cover P hinged to the chamber, and below, also hinged, but to the vertical side of the trough, is the valve P', Figs. 548 and 549. This valve has about the same length as the cartridge, and its function is to hold up the row of cartridges, as shown in the figure, excepting when a fresh one is required, when it drops to resume immediately its previous position. The crank *f'*, the bevel gearing f^2, partly shown in Fig. 548, and the spindle F, receive and transmit the power from the operator to the various parts. Taking the operations in the order given above we have, first, loading.

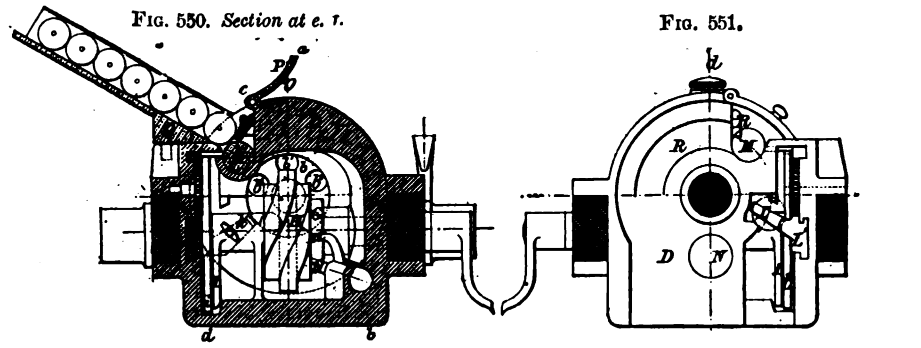
The gun being in such a position that the axis of one of the barrels coincides with that of the plunger M', a position in which the gun comes to a state of rest during each revolution, the small pinion *m* (Fig. 547) imparts a forward motion to the rack M' attached to the body of the plunger M, which is a hollow gun-metal cylinder. Parallel with it, and connected to it by a flat plate m^3, is the rack M' above referred to. The position of this detail in the breech chamber is shown in Fig. 548, where it will be seen that the rack M' lies in and traverses a groove in the chamber, and remains always in contact with the pinion *m*. An alternating motion is imparted to this wheel by means to be presently described, which has the effect of causing the plunger to advance and recede with each charge. On the front end of the plunger is a small finger, the object of which is to hold up the valve P', and so shut off the cartridges in the hopper. If this were not done, the action of the plunger might be interfered with by cartridges getting out of place. As the plunger advances to push home the cartridge, the finger, a little to the front, forces up the valve and keeps it in the proper position until the plunger has completed its forward and backward movement, when the valve, freed from the finger, drops, and another cartridge enters the trough. So soon as the plunger has forced the cartridge into the barrel as far as it can, the barrels begin to revolve, and the base of the cartridge is pressed against the inclined plane, as before described, the loading being completed by the turning of the barrels.

The second operation is the revolution of the barrels. This is effected by the worm H (Figs. 546 and 548) and the pin-wheel *b*, on the end of the shaft B. The form of this pin-wheel is shown in Fig. 546, a section through the breech chamber. On the face of the wheel are five hardened steel circular studs, which gear into the cam H, the motion of which thus determines that of the barrels. The path of this cam is laid out with a

MODERN FRENCH ARTILLERY.



DETAILS OF HOTCHKISS 37-MILLIMETRE REVOLVING GUN.



DETAILS OF BREECH; HOTCHKISS REVOLVING GUN.

straight section in half its length (see Fig. 548), the remainder having a uniform inclination. By means of this straight portion, the barrels are kept motionless at the desired period when the rest of the mechanism is in action.

The third operation, that of firing, is very simple. In one piece, with the worm H, is a snail G (Fig. 546) which operates the striker N'. This latter is a steel rod (Figs. 546 and 548), with a finger *n*, kept in its proper position by the slot in the cylindrical guide at the bottom of the breech. The end of the striker is in contact with a sear spring O (Fig. 546), hinged to the inside of the gun-metal cover of the breech *d*. The relative action of the three parts is as follows: Starting from zero in its revolution, the snail G gradually presses back the finger *n* of the striker, until the maximum point is reached, that shown in Fig. 546, the spring O being fully compressed. Immediately on passing this point the finger is released, and the striker is thrown violently forward by the action of the spring. In the larger calibres, which require two men to operate them, the striker, having been drawn back by the snail, is set at half-cock by the spring connected with the pistol butt, and is released by the firing number pulling the trigger; or if continuous firing is desired this number holds the trigger and the operation is the same as in the smaller gun.

The fourth operation, that of extracting, is equally simple, though not so easily described. The mechanism is shown in Fig. 547. It consists of a rack L', to one end of which is attached a slotted link J, and at the other a crosspiece L is fixed, as shown in the figure. It will be seen (Fig. 548) that the rack L' slides in the recess provided for it in the side of the breech so as to gear into the pinion *m* before mentioned. Fig. 547 shows the side elevation of the extractor with the projecting piece L in the act of removing a cartridge. Movement is imparted by means of the crank I (Fig. 547). The crank is mounted on the shaft F, and is held by locking screws. The stud at the end of the crank marked *i* enters the slot of the link L, and with the revolution of the shaft F gives the required motion to the extractor. This motion is not uniform, it being necessary to allow time for the cartridge to enter the jaws of the extractor, and to stop the traverse for that period during each revolution. Accordingly a part of the slot is curved to correspond with the throw of the crank as shown, but on passing this portion of the path the rack is advanced or withdrawn either to take hold of a cartridge or to withdraw it. The rack L' drives the pinion *m*, which in its turn imparts the necessary reciprocating motion to the plunger M. The face of the rack L' has upon it two concentric jaws with the axis of the gun as a centre. These jaws are placed at such a distance apart that the baseplate of the cartridge can pass between them. After a round has been fired the barrels make one-fifth of a turn, by which time the extractor has advanced to its full extent, that is to say, almost in contact with the back of the disc C, beyond which the base of the cartridge slightly projects. With the revolution of the barrels, this baseplate is passed between the jaws of the extractor. The movement of the

MODERN FRENCH ARTILLERY.

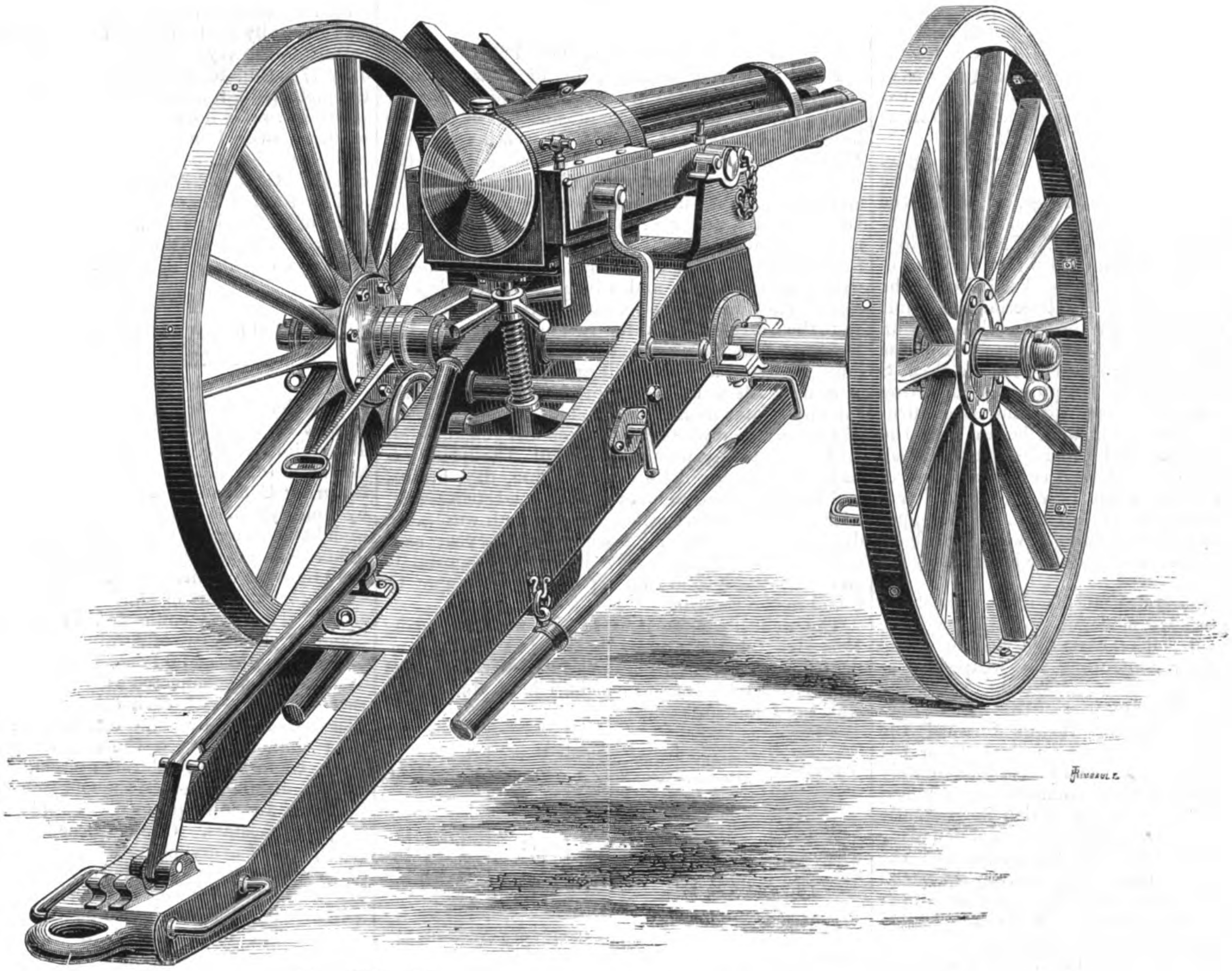


FIG. 552. HOTCHKISS REVOLVING GUN MOUNTED ON FIELD CARRIAGE.

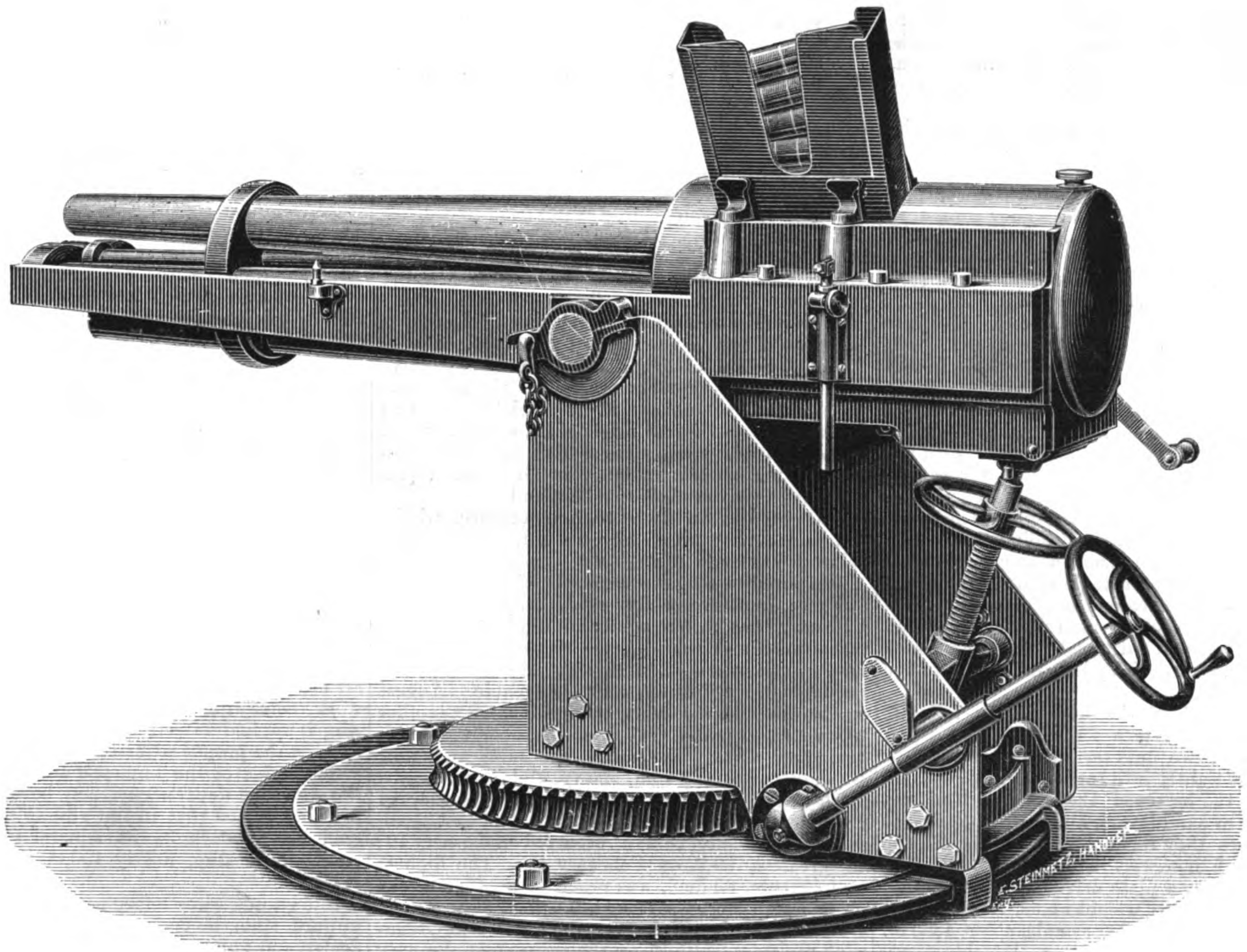


FIG. 553. HOTCHKISS REVOLVING GUN MOUNTED ON NAVAL CARRIAGE.

a Puritan of the olden time (Fig. 10). The newel posts of this grand staircase are each surmounted by the figure of a dolphin in bronze, holding a trident supporting clustering incandescent lights which illuminate that portion of the grand saloon (see page 104). The quarter-deck is treated in warm yellows and gold, contrasting to the delicate white in the grand saloon above. In the social hall, the change is made of producing a tone between those of the quarter-deck and grand saloon. In the large parlour state rooms, which are nearly square in shape, a series of panel work is shown, with a lightly modelled frieze of garlands, treated in soft tints.

The Puritan has in all 364 state rooms. These are in double tiers for the entire length of the main saloon and gallery decks, and upon the main deck there are 139 rooms. On the gallery deck there are 152 rooms, and for considerable area on this deck the state rooms are in treble tiers. This is made possible as the top of the wheels reach only to the base of the gallery deck, thirty additional state rooms on either side being thus secured. In the social hall there are thirty-three rooms, and on the dome deck, ten rooms. The finish of these rooms, especially of these great rooms on the main saloon and gallery decks, is superb. Nothing superior to it is to be found in marine finish under any circumstances elsewhere, nor are the finest houses on land more elaborately and tastefully adorned in their interiors. And let no one suppose that the efforts of the designers and builders of this great ship were directed with a view alone to beauty and magnificence. First of all the safety, comfort, convenience and accommodation of passengers and ship's company have been studied.

So much for the Puritan, the true "Monarch of Long Island Sound," and, indeed, of all American waters. The increase of business soon rendered the supply of still another steamboat for this line imperative, and in 1888 the keel of a new ship, to be called the Plymouth, was laid in the same yard at Chester that had witnessed the construction of the Pilgrim and Puritan, the Messrs. W. and A. Fletcher Company, of New York, being again the sole contractors for the building and fitting of the production.

The Plymouth was launched on April 3, 1890. In many respects, and especially in the design and construction of her machinery, this vessel differs from all her predecessors, and in truth, from all steamboats of her class to be found anywhere. She is a beautiful craft to look upon; her proportions being ample and her lines as delicate and graceful as those of an artistic piece of sculpture.

	ft.	in.
Length over all	366	0
,, on water line	351	8
Breadth over guards	87	0
,, of hull	50	0
Depth at lowest point of sheer	21	0
Draught of water, light...	11	0
Distance from keel to topmast head ...	119	0
,, ,, dome deck	55	3
,, ,, top of house on dome	59	3

Like the Pilgrim and Puritan, the Plymouth is constructed on the double hull, bracket plate and longitudinal system, every effort having been directed toward securing absolute safety for the ship as regards sinking or destruction by fire. In general appearance and distribution of features she nearly resembles the Puritan, having the same number and arrangement of decks and appurtenances, promenades and belongings as that notable ship, while within her saloons, dining hall, state rooms, &c., she nearly duplicates the same departments in that vessel, some minor deviations from the Puritan's internal construction having been made.

The construction of the Plymouth will admit of her carrying a much larger burden of freight in proportion to her size than any other passenger vessel of the line. The bulkhead dividing the quarter-deck from the main deck forward is only 100 ft. from the stern, all forward of this bulkhead on the main deck being devoted to freight stowage. Aft of the quarter-deck, in what is known as the ladies' cabin in the other ships of the line, some new arrangements have been introduced.

The machinery of the Plymouth forms, perhaps, the most interesting feature of her equipment. She has no "working beam," the machinery in its entirety being "below decks." She is fitted with a four-cylinder, double-inclined, triple-expansion engine of 5500 indicated horse-power. The high-pressure cylinder, 47 in. in diameter, takes steam direct from the boilers, at a maximum pressure of 160 lb. per square inch. Alongside of the high-pressure cylinder is the intermediate cylinder 75 in. in diameter, taking its supply of steam from the high-pressure cylinder exhaust. The high-pressure and intermediate cylinders are placed forward of the centre of the shaft, and are connected to two different crank-pins, placed at right angles to each other. Aft of the shaft are placed the two low-pressure cylinders, each 81½ in. in diameter. These cylinders take their supply of steam from the exhaust of the intermediate cylinder. One low-pressure is connected to the same crank-pin as the high-pressure cylinder, and the other to the same crank-pin as the intermediate cylinder. All of the pistons have a stroke of 8 ft. 3 in. The centre lines of the cylinders with the lines of the engine keelsons form a double isosceles triangle, with the centre of the shaft as the apex. This arrangement makes a port, starboard, and a centre shaft, with two double cranks placed, as has been mentioned, at right angles to each other. Each of the two low-pressure cylinders is supplied with its own air pump and surface condenser, with an independent centrifugal circulating pump. All of the cylinders have poppet valves, operated by double eccentrics and link motion, which, being shifted by an independent steam engine, makes the starting, stopping, and reversing of main engine very simple and easy. The high-pressure cylinder alone has an adjustable drop cut-off. On all the other cylinders the cut-off is fixed, and resembles those of the Puritan, though smaller. The paddle-wheels are 30 ft. in diameter outside of buckets. Each wheel has twelve curved steel buckets, each bucket being 4 ft. wide and 13 ft. 3 in. long. The wheels are very strong throughout, it being the intention to make the Plymouth as good for winter service as for summer.

In another compartment, separated from the engine inclosure by a water-tight bulkhead, are the main boilers, eight in number, of the style termed "Scotch boilers." Each of these is 11 ft. 4 in. in diameter and 13 ft. 1 in. long, and has two corrugated furnaces. The boilers are placed athwartships and in the centre of the vessel, back to back, making two fire-rooms, one on each side of the ship. In the engine compartment are two large steam fans, which ventilate the engine room, and at the same time supply the fire-room with extra air, or furnish forced blast under the grates. There is also a steam fan which ventilates the forward hold, and supplies additional air to the fire-room. The smoke from the eight boilers enters into one smokestack only, differing in this respect from every other boat on the line. This smokestack is 10½ ft. in diameter, and the top of it is 86 ft. above the water level. The boilers have been built for 170 lb. of steam and tested by a hydraulic pressure of 260 lb. per square inch; though, as mentioned before, the maximum working pressure of steam is 160 lb. per square inch. The boiler and smokestack inclosures are of steel throughout, so that no fire can be communicated from this part of the boat. There are also on the main deck two large Blake duplex pumps which have sea connections for use in case of fire, and bilge suctions connected to the different water-tight compartments.

The interior finish and ornamentation, joiner work, &c., of the Plymouth, is almost identical with the same features of the Puritan. The dining room is 84 ft. long, and seats 140 persons at one time. There are 250 state rooms.

The Plymouth was designed by Mr. George Pierce, supervisor of the Old Colony Steamboat Company, and was constructed under his personal supervision. The contractors for the vessel complete and builders of the engines were the W. and A. Fletcher Company, New York; hull builders, the Delaware River Iron Shipbuilding and Engine Works, Chester, Pa.; joiner work was done by William Rowland, of New York; electric lighting by the Edison General Electric Company.

This furnishes an outline of the features and appointments of the Fall River Line, so far as passenger transportation is concerned. It has already become apparent, however, that with all this magnificent and costly provision of ships, the line has not yet sufficient facilities to meet the demands of its constantly increasing passenger business, and the keel of another leviathan steamboat will shortly be laid, to provide for this shortcoming. It is safe to assert that the new construction will outdo all that have preceded, since every advantage will be taken of experience gained both in building and running the vessels heretofore provided; so that the public and all interested may confidently look for a wonderful result in shipbuilding as the outcome of this next essay of the line managers.

But another department of the operations of the Fall River Line demands and must receive attention. The enterprise of this concern is by no means confined to the transportation of passengers over the Long Island Sound route. It has a freight transportation department as well, and the volume of its business in this division has become truly enormous, while, like the passenger movement, it is increasing with every month's passage.

The freight steamboats of the Fall River Line are four in number, and they were constructed especially for the service they perform. Their names are the City of Brockton, City of Fall River, City of New Bedford, and City of Fitchburg. In illustration of the facilities of this department the following description of the two latest built additions to the freight fleet of the line is given.

While the travelling public is tolerably well acquainted with the passenger steamers and accommodation of the Fall River Line, few people understand the magnitude of the facilities of this line for freighting, or the business in this department transacted upon it. Of the passenger steamers the Providence has a carrying capacity of 35 long cars, and the Old Colony of 27 cars. Of the freight boats the City of Fitchburg will accommodate the contents of 50 cars, and the City of New Bedford an equal number. The City of Fall River will carry freight equal to 80 car loads, and the City of Brockton will carry easily 100 long car loads of freight. The boats ply between New York as the western terminus of the line, and Newport, Fall River, and New Bedford as the eastern terminus, so far as the water transportation is concerned. Passages are made in the night, usually two boats each night, each way, while one steamer is run every week day between New Bedford and New York. These boats run full loaded all the year round.

It is usually supposed that the business of the Old Colony Railroad and the Fall River Line is purely local; and so, indeed, it is, compared with the transactions of the great trunk lines and their connections on the grain, stock, coal, and provision moving highways of the country. But there is a sense in which the Old Colony corporations do a very important through business, constant in its river-like flow, and ever increasing in volume. The Old Colony Railroad Company and the Old Colony Steamboat Company are separate and distinct corporations, managed and their accounts kept as such; yet virtually they are one and the same institutions.

The City of Brockton was the last freight steamboat built for this line, and her description may be taken as illustrative of all the vessels of this ownership in that department. She is a steamer of about 3000 tons burden; never was a more beautiful or more complete and thoroughly finished steam vessel for the service intended put into the water than the Brockton.

The hull of this vessel was built by Messrs. Montgomery and Howard, Chelsea, Mass., and the joiner and upper works by the Old Colony Steamboat Company, at their shops at Newport, R.I. Her dimensions are as follows:

	ft.	in.
Length on water line	272	0
,, over all	287	0
Breadth of beam	42	4
,, over guards	75	0
Depth of hold moulded	18	8
Draught of water, light	9	6
Depth of water, loaded with 800 tons (100 cars) freight	13	0

The engine was built by the W. and A. Fletcher Company, North River Iron Works, New York City, and is a compound vertical surface condensing beam engine of 2500 horse-power. High-pressure cylinder 44 in. in diameter, by 8 ft. stroke of piston. Low-pressure cylinder 68 in. in diameter by 12 ft. stroke of piston, both fitted with Sickle's dash-pot cut-off valve gear. Steam is supplied by two Redfield boilers, 17 ft. 6 in. wide by 16 ft. long, each boiler containing two shells 7 ft. 6 in. in diameter, with return tubes 3½ in. in diameter. Each boiler has a superheater of 56 in. diameter inside, 8 ft. diameter

THE STEAMER "PURITAN;" FALL RIVER LINE.

FIG. 9. STAIRCASE IN THE GRAND SALOON.

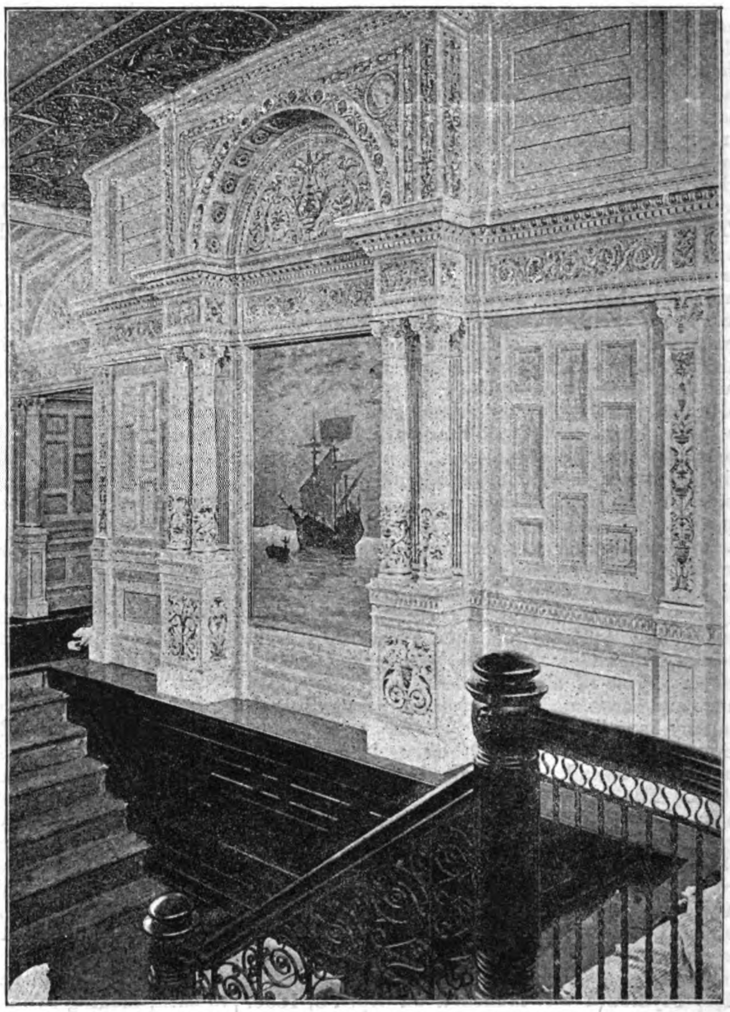


FIG. 10. STAIRCASE IN THE GRAND SALOON.

outside, and 12 ft. high. The wheels of the engine are of the "feathering" type, 25 ft. 6 in. in diameter outside the floats, and 10 ft. 6 in. face, constructed very strong to enable the boat to run the ice formed in severe winters. The entire main deck, with the exception of the inclosure around the engine and boiler chimneys, is used for freight, and when filled all doors to freight space are closed and locked effectually, making the entire boat a sealed freight conveyance. A peculiarity of this vessel is that she has neither hog-frame nor paddle-boxes, the wheels being small and of the most improved construction. The space usually taken up by paddle-boxes is in this craft used for freight. The speed of this boat is eighteen miles an hour. With this efficient service the Fall River Line is able to take all freight brought to either terminus every day, delivering the same to the other end early the following morning. The City of Brockton was designed and constructed under the supervision of Mr. George Pierce, supervisor of the Old Colony Steamboat Company.

The Fall River Line transports more merchandise yearly than the city of Boston exports, the steamers of the line carrying in 1885 freight to the value of upwards of 120,000,000 dols. Of course the increase has been large since that time, and the volume of traffic is constantly growing.

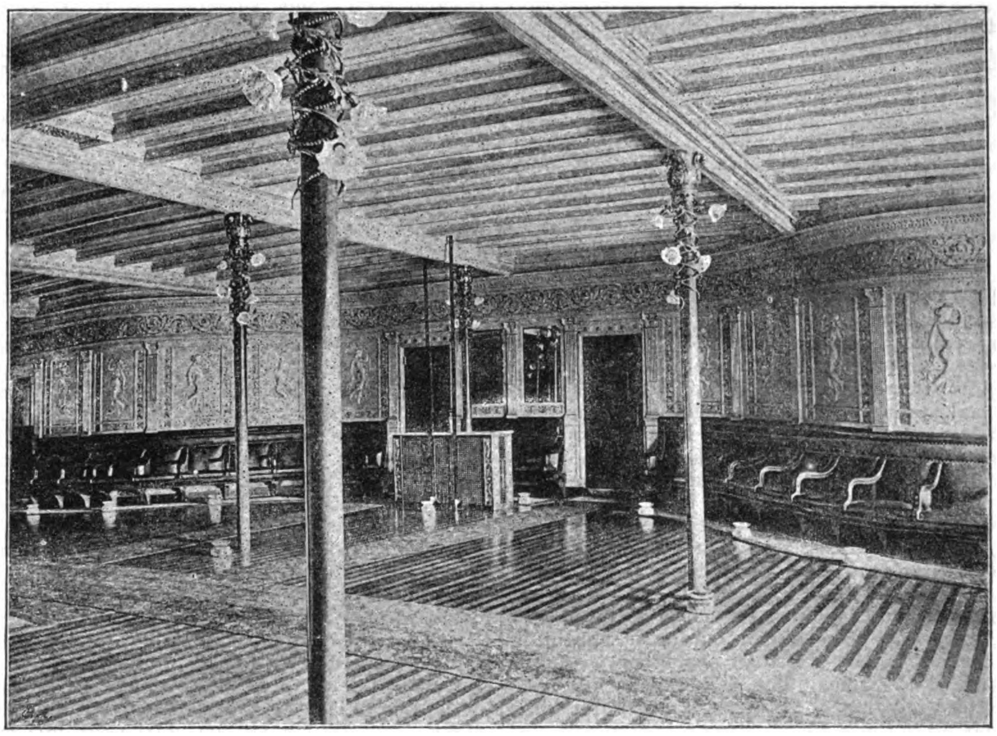


FIG. 11. THE SMOKING ROOM.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, January 9, 1891.

THE steel railmakers, after several unsuccessful efforts, are still unable to establish the minimum price of steel rails at mill at 30 dols. One or two makers have been accepting contracts at 27 dols. and 27.50 dols., which is likely to be the ruling price. Steel billets have dropped in the west to 25.50 dols. Nail slabs have also dropped 1 dol. Eastern quotations for billets are 28.50 dols. Spiegel has dropped to 29 dols. Crude iron has weakened 25 cents, and shaded quotations have been heard of on plate and structural iron also. There is a general strike in Northern Alabama coal mines, and sixteen furnaces have been banked in consequence. In Ohio twenty-five furnaces have been blown out or banked. This will bring about a restriction which the trade at large will not regret, but the intention is to blow in as soon as coal can be had. Four thousand miners near Pittsburg have gone on a strike for higher wages at a time when their services can be well dispensed with, and 3000 miners in another portion of the State have also quitted work; several thousand miners in the mountain region are on the eve

HOTCHKISS REVOLVING CANNON AND AMMUNITION FOR FLANK DEFENCE.

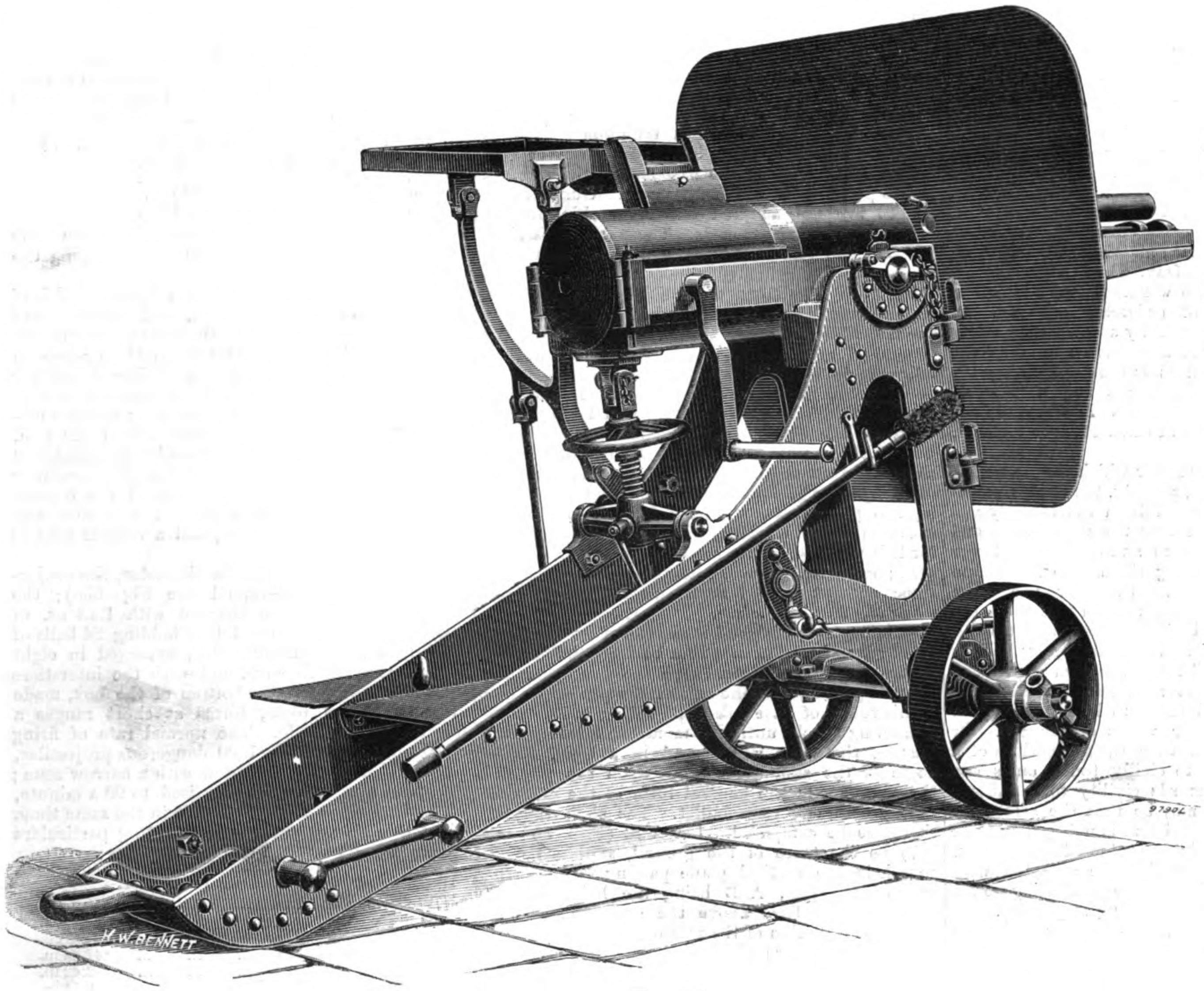


FIG. 555.

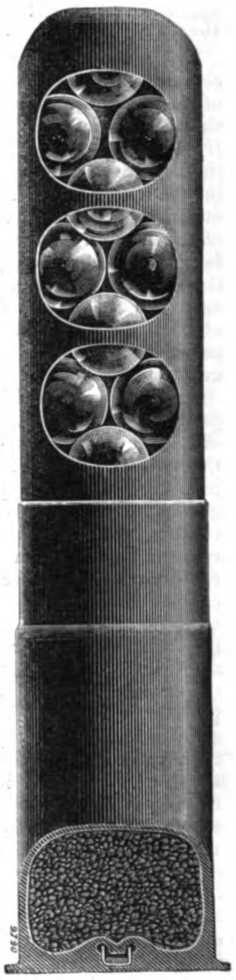
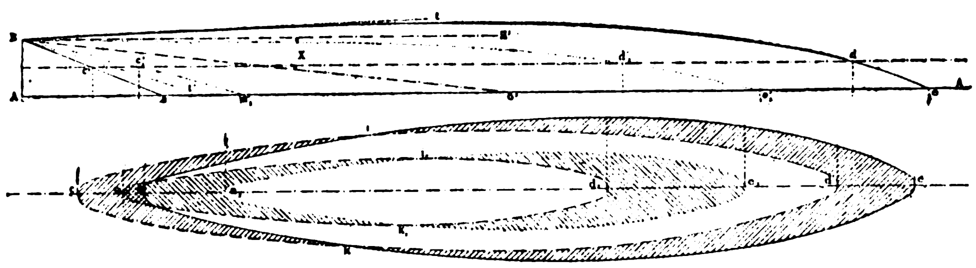


FIG. 558.



FIGS. 556 AND 557. DIAGRAMS SHOWING DESTRUCTIVE ZONE OF FLANK DEFENCE GUN.

Total weight of cartridge :	
For ordinary shells	22 oz.
„ steel shells	23.8 „
„ mitraille cases	25.4 „
Total length of cartridge	6.57 in.
Thickness of plate perforated by steel shell	.12 „
Initial velocity of ordinary shell ...	1319 ft.

2. *Field Gun and Carriage*, 37-*Millimetre* (1.46-In.).—In its construction this gun is similar to the naval arm of the same calibre, except that the firing crank is placed at the side of the breech piece instead of being brought round to the back; the frame is heavier, to adapt it to the special service for which it is intended. The frame, carriage, limber, and ammunition chest are all of steel, and the shield, also made of steel, serves as a seat to the men serving the gun when not in action; the recoil is taken up by a friction brake acting on the centres of the wheels. The ammunition chest is divided into two compartments, the upper one of which contains 200 cartridges arranged in perforated trays; the lower compartment contains ten cases each holding ten cartridges for rapid firing, as well as duplicate parts, tools, &c. The special service of the gun is for reinforcing ordinary field batteries for protecting trenches and permanent outer works, and for making an enemy's counter-works untenable.

TABLE LXXXI.—*Particulars of 37-Millimetre Revolving Field Gun with Carriage.*

Weight of gun...	495 lb.
„ ordinary shell	16 oz.
„ mitraille case	20 „
Initial velocity	1319 ft.
Weight of carriage	550 lb.
„ shield and fittings ...	220 „
Height to centre of trunnions ...	35.04 in.
Diameter of wheels	47 „
Limiting angle of fire (elevation) ...	from + 18 deg. / − 5 deg.
„ „ (direction) ...	4 deg.
Weight of limber empty	659 lb.
„ „ loaded	1067 „
Number of rounds carried	300
Total weight of gun, carriages, ammunition, &c.	2376 lb.

3. *Naval Gun and Carriage*, 47-*Millimetre* (1.85-*In.*).—This is an exclusively naval gun, adapted for the same work but of a heavier character, than the 37-millimetre piece; its weight renders it unsuitable for light boat service. The support is an open iron framework with a socket at the top and a spring device that absorbs the recoil; the pivot, like that of the 37-millimetre, is forked and carries the trunnions. The gun is trained with a shoulder-block, and it can be fired either in volleys or in separate rounds; the man training the piece fires it with a trigger, while a second turns the handle that is stopped automatically at the moment of firing; in this way, when desired, a round can be fired with each revolution of the crank. This gun is specially designed for repelling torpedo boat attack and for penetrating the unarmoured parts of large vessels.

TABLE LXXXII.—*Particulars of 1.85-In. (47-Millimetre) Revolving Naval Gun with Deck Carriages.*

Weight of gun...	1265 lb.
„ stand	620.4 „
Total weight	1885.4 „
Length of gun	68.11 in.
Diameter of bore	1.85 „
Length of bore (25 calibres) ...	46.25 „
Limiting angles of fire elevation ...	+ 20 deg
„ „ „ depression...	−20 „
Ordinary Shell:	
Weight	37.9 oz.
Bursting charge	1.58 „
Steel Shell:	
Weight	38.35 „
Bursting charge	1.58 „
Mitraille Case:	
Weight	38.35 „
Number of balls	30
Ordinary powder charge	7 oz.
Total weight of cartridge :	
Common shell	53.12 oz.
Steel shell and mitraille	54.71 „
Total length of cartridge	9.25 in.
Initial velocity	1394.5 „
Thickness of plate perforated ...	.18 „

4. *Naval Revolving Gun*, 53-*Millimetre* (2.09-*In.*) *and Carriage*.—This is the heaviest type of Hotch-

47-MILL. HOTCHKISS REVOLVING CANNON.

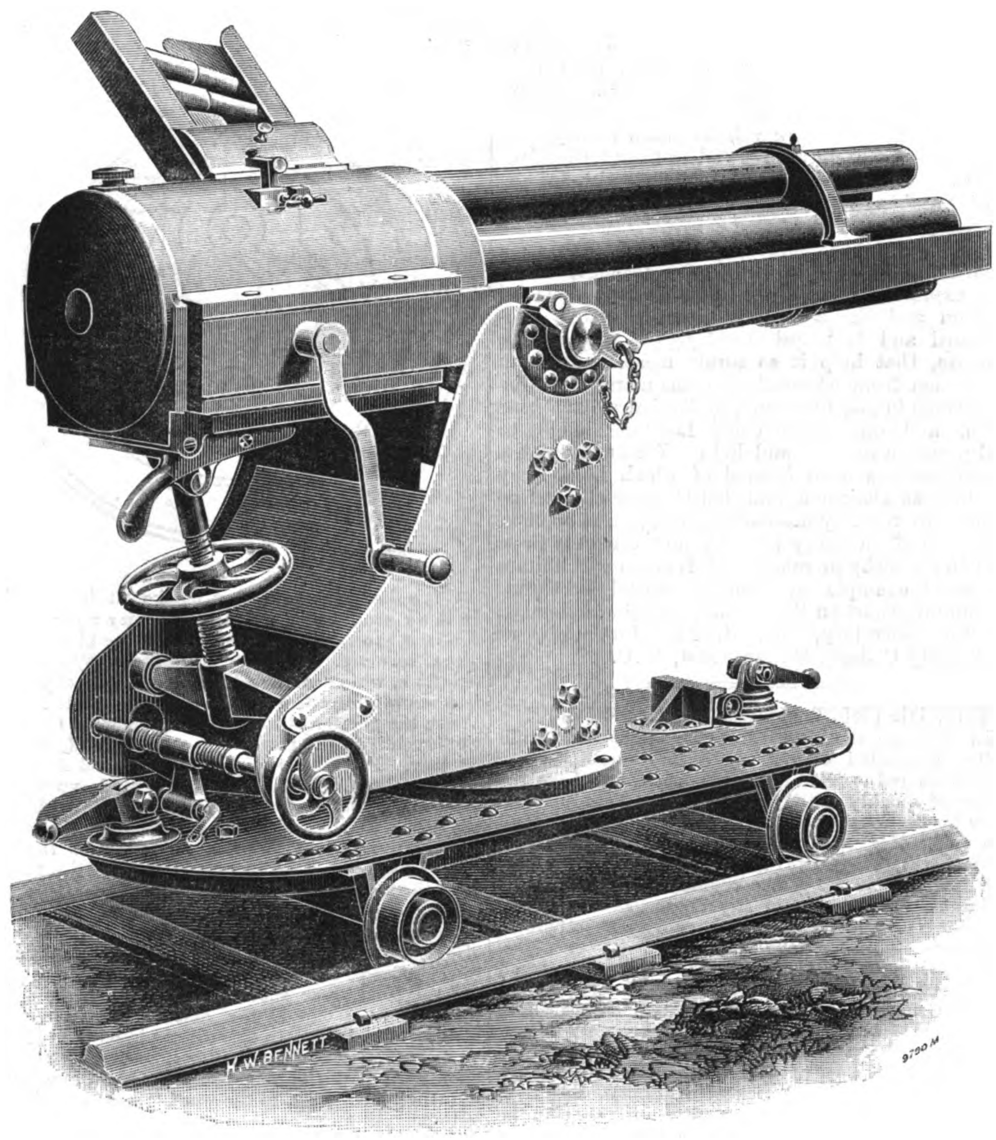


FIG. 554.

kiss revolving gun yet made; in construction it is practically similar to the 37 and 47 calibres. Three men are required to serve it, one for training, a second to turn the firing handle, and the third for supplying the cartridges; the rate of firing is from 30 to 40 rounds per minute. The carriage rests on a bedplate bolted to a ship's deck, or secured to proper foundations within a fort. By means of an inclined rod and handwheel operating a pinion, the gun and its frame can be turned around a central toothed wheel secured to the bedplate. Training is completed by an elevating and lowering screw and wheel, secured between the side plates forming the frame; to the lower edge of these plates brackets are bolted, which serve as guides in connection with the edge of the baseplate when the gun is turned round.

TABLE LXXXIII.—*Particulars of 53-Millimetre (2.09 In.) Revolving Gun on Pivotted Carriages.*

Weight of gun...	2200 lb.
Length of bore (27 calibres)	56.34 in.
Diameter of bore	2.09 ,,
Length of gun...	84.25 ,,
Limiting angles of fire elevation ...	+15 deg.
,, ,, depression...	−10 ,,
Common Shell:	
Weight ...	3.58 lb.
Bursting charge	2.47 oz.
Steel Shell:	
Weight ...	3.58 lb.
Bursting charge	2.12 oz.
Mitraille Case:	
Weight ...	4.18 lb.
Number of bullets	58
Powder Charge:	
Shell	14.4 oz.
Mitraille	10.94 ,,
Total weight of cartridge:	
Shell ...	5.16 lb.
Mitraille	5.61 lb.
Total length of cartridge	12.40 in.
Initial velocity	1394.5
Thickness of plate perforated by steel shell	2.4 in.

CLARENCE BRIDGE.

ON our two-page plate, and also on page 134, we publish illustrations of a new bridge lately erected over the River Taff in South Wales. In an early issue we shall give further engravings of this work with a complete description. The bridge is of steel, 40 ft. wide, and consists of a centre swinging span of 190 ft. 8 in., and two end spans, each 132 ft. The engineer is Mr. W. Harpur.

DEATH OF MR. W. W. KELL.—Mr. W. W. Kell, of Springfield House, Bramley, died on Tuesday. The deceased had been an official of the Great Northern Railway for thirty-eight years. During twenty years of that time he occupied the position of engineer to the company for the Leeds district. Failing health compelled him to retire at the end of last year.

THE JUNIOR ENGINEERING SOCIETY.—The sixth annual dinner of the Junior Engineering Society was held on Friday evening last in the Holborn Restaurant. Professor Sylvanus Thompson, B.A., D.Sc., being in the chair. The meeting proved a great success, the attendance numbering upwards of sixty, though several guests, amongst whom was Sir John Fowler, were unable to attend at the last moment. In responding to the toast of the evening, Mr. W. J. Tennant, the chairman of the Society, referred to the encouraging success which had attended their body during the past year. The membership of the Society is now upwards of 150, and amongst its past-presidents and vice-presidents are numbered some of the most distinguished engineers and scientific men of the day. Frequent reference was made during the evening to the very successful holiday tour organised by the Society last year, in the course of which the Forth Bridge and some of the most important engineering works in the north of England were visited. A similar tour, it was stated, is being arranged for the coming summer.

NAVAL AND MERCANTILE SHIPBUILDING IN SPAIN.

THE Spanish Government have now definitely arranged to build two cruisers, each of 9000 tons displacement, with a speed of 22 knots, and an indicated horse-power of 20,000. These will be similar to the British cruisers Blake and Blenheim, and with them will rank among the fastest and most powerful cruisers afloat, having great offensive powers, while their speed will enable them to get beyond the reach of ironclads. These vessels form part of the "new navy," for which the legislature voted 2,000,000*l*. sterling two and a half years ago, and of which six vessels are already in the hands of contractors in the dockyards and at Bilbao. One was launched quite recently by the Queen Regent from the works of Messrs. Martinez-Rivas Palmer, and on that occasion we gave a description of the ship and of the works.* It is expected that one of these ships will be built at Bilbao and the other at Cadiz, at least plans have been submitted for the consideration of the Government on behalf of the firms at these places. There is no shipbuilding yard at present in Cadiz capable of coping with this work, but one is now being laid out. The wisdom of the Government in giving the promise of such an important contract to a district so unfavourably situated as Cadiz, has been adversely commented upon, but the claims of this part of Spain for a share in the distribution of the money has been contested in Parliament by the representatives of the district, and with such effect that the Government have had ultimately to yield. It is rumoured at Bilbao that an arrangement may be arrived at whereby the firm "La Sociedad Anonima de les Astilleros del Nervion" (late Martinez-Rivas Palmer) may supply the Cadiz firm with their plans, and undertake at the same time on their behalf the technical supervision of the work.

While the Government are thus vigorously extending their means of defence the spirit of private enterprise is equally active, as it is proposed to start an express line of steamers from Vigo to New York. The vessels it is proposed to run are to be on the same lines as the Inman and International Company's famous steamers City of Paris and City of New York. They are to maintain at sea a speed of at least 21 knots. The distance from Vigo to New York is practically the same as from Liverpool to New York, approximately 3000 miles. As Vigo has a splendid port, ships at all states of the tide can enter, and thus avoid any delay due to considerations of bar or tide, as at Liverpool. On this route, too, there are comparatively smooth seas and it is free from ice and fogs. The maximum power of the machinery—other conditions being satisfactory—may therefore be maintained from the time of starting until the close of the voyage. In the year 1885 His Excellency Don Arturo de Marcoartu read a paper before the Aberdeen meeting of the British Association "On Casualties at Sea," and recommended a route across the Atlantic, ending at Vigo, as the safest track for navigation between the United States and central and southern Europe. In May, 1887, he moved for leave in the Spanish Senate to introduce a Bill to establish a fast line of steamers between a western harbour of the Iberian peninsula and the United States. At present Signor Don Marcoartu is in Bilbao visiting the extensive works of the Astilleros del Nervion, inquiring into the important technical considerations involved for establishing such a line, with a view to placing two steamers on the route. There is every prospect that the project will be successfully carried through. It is already exciting keen interest throughout Spain, and it will probably be supported and subsidised by the Government. Such a line would be largely patronised by tourists to Europe, as it would land them in one of the most charming and romantic countries in the world. Travellers from the Western Hemisphere arriving in Great Britain, and extending their tour to the south of Europe, could return to their homes by this pleasant route.

It may be added that the Bilbao works of Martinez-Rivas Palmer—amongst the most completely equipped and best organised establishments in Europe—have been converted into a limited liability concern, under the title La Sociedad Anonima de les Astilleros del Nervion, with a capital of

* See ENGINEERING, vol. l., page 317.

of these screws the strands of the conductor can be rapidly opened out and a perfect contact made with the piece F, which also carries at the end the screw K, and the whole is covered with a rubber sleeve long enough to pass well over the jute envelope of the conductor to which it is bound by galvanised iron wire in the way already described. For cables made with an insulated wire, serving as a control conductor, the type shown in Fig. 29 is employed. The piece F is made somewhat longer and is provided with a stopper H^1 of ebonite; in this stopper is formed a horizontal opening to which the insulated wire F is led through the passage in the piece F. A screw S in the ebonite makes contact with the stripped part of the control wire and serves as a terminal for this conductor. The layers of insulation are stripped at J, B, and J^1, and the whole joint is made good with a rubber tube fastened with a lapping of wire. Fig. 30 shows another method of protecting and leading off the control wire.

Sleeves are used to insure a good contact between two cables in such a way that the contact itself, as well as the insulation, may be perfectly protected from humidity. Such unions are made in one way by galvanised brass jaws gripping the conductors and inclosed in cast-iron boxes made in two parts and bolted together, the internal space being filled with asphalte. Junction sleeves are employed to make a connection between the ends of two conductors placed end to end; branch sleeves are also employed for making connections between conductors at right angles to each other. Figs. 33 and 34 illustrate such a junction between large cables and between control wires; the union is made more perfect by means of a cast-iron casting in which grooves are provided for tarred hemp packing, so that the conductors are practically quite protected from the action of the air and moisture. These sleeves differ only in their dimensions according to the size of the conductors.

There are a certain number of junctions on large electrical circuits, such as we are considering, which must be made so as to give facilities for testing, and for making or re-making contacts easily; there are, besides, certain points on a system, where it may be necessary from time to time to add additional lines connected with those already laid. Again it is desirable to provide places on the system where circuit-closing appliances can be introduced in order to cut out any defective lengths that may interfere with the proper working of the whole *réseau*, till they can be repaired. It is with these different objects that the so-called "distributing boxes" are introduced at various points of the lines, as well as the circuit-closing boxes. The former consist of a cast-iron box, provided with a close-fitting cover, in which the bronze junction pieces are placed; in the sides of the box, holes are made, equal in number to that of the cables which are brought together within it. When these cables are of very large section, there is placed at each hole a cast-iron sleeve (see Fig. 31) into which the cable A passes, protected by an end piece, such as we have already described, and which extends into the interior of the box; the space between the cable and the sides of the box is filled with melted asphalte poured in through the opening *g* left in the top of the box. To complete the joint the two conductors are connected by a plate of red copper, when the joint is to be permanent; when it is to serve as a circuit-closer, that is in case of an accident on the line, a lead connecting plate of a fixed section is employed. The joints are made as shown at *i, f, f'*. Fig. 32 represents a distributing box for a system of two conductors, but adapted to receive sixteen conductors of a maximum section of 1000 square millimetres; the copper strip connections are shown at B, E, and K; the sleeves St, &c., are of the same character as those already described. Figs. 35 to 37 show a box of the same character but intended for a system of five conductors; in this system of distribution the sections are usually very much reduced and a sleeve of special construction is employed for each group of five conductors, so that a box for twenty conductors would only have four sleeves; when these boxes are intended to receive auxiliary conductors (see Figs. 38 to 40) two special sleeves are also provided; the section of these conductors is often very considerable. It is sometimes convenient to be able to close the current from a subscriber without entering his premises, as for example in the event of fire, or misuse of current; for this purpose a special cut-out box is employed.

(*To be continued.*)

MODERN FRENCH ARTILLERY.

No. LIV.

HOTCHKISS REVOLVING CANNON—*continued.*

THE ammunition supplied to the Hotchkiss revolving cannon is of three kinds: Cast iron shell, steel shell, and case shot, illustrated by Figs. 559, 560, and 561. The two former have the same general appearance and are of the cylindrical ogival type; the point of the steel shell (Fig. 559) is sharply pointed, and the fuze is inserted in the base; the cast-iron shell has a percussion fuze fitted to the front end, which is truncated to form a seat. A number of grooves are cut around the body of the projectile, as shown, and over this is forced a sheet-brass belt. When the gun is fired this belt is forced into the grooves, and at the same time is compelled to take the rifling, the grooves affording space for the flow of the metal. Both classes of shell are shaped with great care and turned true; those of steel are tempered. The case shot consists of a shell of thin brass filled with lead balls, the intervening space being filled with sawdust. Percussion

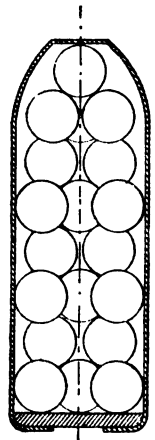


FIG. 561.

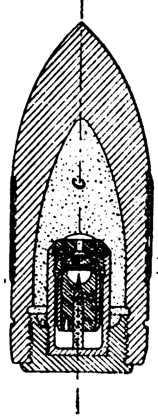


FIG. 559.

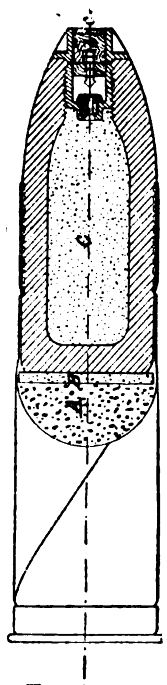


FIG. 560.

fuzes only are used, and are quite similar to those for the rapid-firing projectile, except that the combination time and percussion fuze is peculiar to the latter. The base of the steel shell is closed with a steel screw plug which contains the fuze.

With regard to the fighting properties of the revolver cannon, it happens that the experience gained in actual warfare, which is worth far more than that obtained on trial grounds, is confined to the 37-millimetre calibre; the information is, however, thoroughly reliable, and was gathered in different parts of the world—at Tunis, Tonquin, China, and Peru, and under very varying conditions. Referring to the bombardment of Sfax in the Tunisian campaign, it is reported "that the revolving cannon were used by the gunboats anchored at about 2500 yards from shore, and by small boats and steam launches that were employed in the attack and landing; this cannon was extensively used, and its effect has been marvellous. All the boats and launches were armed with Hotchkiss guns placed in their bows. The fire of these pieces swept and cleared the shore of the enemy, and largely contributed to the capture of the shore batteries and that of the batteries forming the angles of the town. In the attack on the batteries the fire of the Hotchkiss was directed against the embrasures, and the projectiles passing in and which struck the oblique cheeks of the embrasures were seen bursting in the interior of the batteries and completely prevented the enemy from working their guns. The distances of the fire from the boats varied from 500 to 1500 metres, owing to the irregularity of the line of boats." Of the fighting during the Chinese campaign, two United States officers reported of the 37-millimetre revolving gun in reference to the fighting on the Min River, as follows:

"Aside from the detail of the forces engaged on both sides, and the skill of the naval bombardments, which give us no new information, there is one point which deserves special consideration.

"The result of the fight turned in favour of the French fleet on account of its armament of revolving cannon and the superiority of its torpedo service. The power of the revolving cannon, their inestimable value in naval engagements', and the importance of a well-organised torpedo service, were plainly visible to all naval people.

"A shower of shell fired by the Hotchkiss revolving cannon from the tops of the French vessels swept the enemy down like grass under the scythe. Reliefs could not get on deck fast enough to fill the gaps in the ranks of the Chinese gunners. The little shells pierced the rails and bulwarks of the vessels, and their explosion spread death in all directions. The torrents of fire shed on the Chinese vessels were so murderous that it is safe to estimate that 80 men out of every 100 manning the Chinese squadron were killed."

Much the same story is told by the correspondent of the *Army and Navy Gazette* in describing the blockade of Callao by the Chilian fleet.

"At daylight on December 6, three Chilian torpedo boats, a 21-knot Yarrow, a 15-knot American, and a small 10 or 12-knot Thornycroft boat, armed with spar torpedoes and Hotchkiss guns, met a large Peruvian decked gun-vessel, carrying two guns and about twenty or thirty men, two miles from the docks.

"A running fight ensued, the Peruvians retreating under the protection of the batteries, losing several men. The Chilians had now to retire in their turn, and before the Yarrow could reach the shelter of the Island of San Lorenzo, she filled and sank, losing several men. She has since been raised. Not much damage was done on either side, but the noticeable part was the behaviour of the Hotchkiss guns, in comparison with the 20-pounders of the Peruvian boat. The Hotchkiss fired, as nearly as one could calculate, about 20 dangerous little shell, over 1 lb. weight, every minute, with the accuracy and ease apparently of a rifle. On the other hand, the Peruvian boat's guns were seldom discharged oftener than once in two minutes, and then evidently with a wild aim, the crew being several times driven from their guns by the Hotchkiss fire. Again, only the Peruvian stern gun could be fired when retreating, while the Hotchkiss had an all-round fire. The total weight of projectiles fired by the Hotchkiss was probably double the expenditure of the Peruvians, gun for gun; and if the Chilians could have prevented the gun-vessel from reaching the protection of the shore batteries, they would probably have taken her, by simply clearing her deck of men. The Yarrow boat was, it is said, struck by a shot from the shore."

The foregoing quotations tell the story the Hotchkiss revolving gun has played in warfare, and fully establishes its character, far more completely than official tests could do. Nevertheless the latter are all important as indicating the various ballistical characteristics of the weapon, and we shall briefly place on record a summary of the more important ones. Table LXXXIV. is a firing table for the 37-millimetre gun, compiled from experiments conducted by the French authorities at Gâvre, and from the same source is Table LXXXV., giving the penetrating power of the gun:

TABLE LXXXV.—*Penetrating Power of Cast-Iron Projectiles Fired from the 37-Millimetre Revolving Gun.*

Target.	Thickness.	Angle of Target.	Range for Complete Penetration.	Remarks.
	in.	deg.	yards.	
Steel plate ..	¼	0	3280	Shell bursts on piercing plates of ¼ in. and $\frac{9}{16}$ in., or oak timber 4 in. and 11¾ in., scattering fragments behind target.
		20	3060	
		30	2620	
" .	$\frac{9}{16}$	0	545	
		20	437	
		30	273	
Oak timbers ..	4	0	4375	Pierces plate ⅜ in. at 0 deg.; ¾ in. at 20 deg., and ⅜ in. at 30 deg.
		30	4155	
" .	11¾	0	875	
		30	437	
" ..	18	90	At the muzzle	Thickness of oak required to stop shell at muzzle 27½ in.
" ..	15¾	30	" "	

Like the actual experiences the test trials are all of them old, but are none the less interesting on

TABLE LXXXIV.—FIRING TABLE FOR 37-MILLIMETRE HOTCHKISS REVOLVING CANNON, COMPUTED FROM THE "GAVRE" TABLE.

Shell.

Distance between sights	33.34 in.
Angle of jump	4 in.
Charge	2.8 oz.
Mean weight of projectile	1 lb.
Initial velocity	13.19 ft. sec.

Range.	Inclination.	Drift.	Time of Flight.	Angle of Fall.	Final Velocity.	Marks on Sight Bar.	Drift Marks.	Mean Deviation.			Dangerous Space for Target 5½ ft. High.	Highest Point of Trajectory.
								Range.	Drift.	Height.		
yards.	d. m.	yards	sec.	d. m.	ft.	in.	in.	yards	yards	yards	yards	ft.
100	0 06	0.01	0.2	0 11	1234	0.058	0.003	22.3	0.06	0.07	Total	
200	0 17	0.04	0.4	0 24	1161	0.164	0.007	21.3	0.12	0.14	range	
300	0 29	0.09	0 6	0 38	1091	0.281	0.010	20.5	0.19	0.22	217	
400	0 42	0.16	1.0	0 52	1037	0.406	0.014	19.8	0.25	0.30	150	
500	0 56	0.27	1.3	1 09	987	0.543	0.018	19.1	0.32	0.39	113	14
600	1 10	0 43	1.7	1 28	944	0.679	0.023	18.5	0.42	0.49	90	
700	1 25	0.64	2.0	1 49	906	0.824	0.027	18 0	0.50	0.57	74	
800	1 42	0 87	2 4	2 12	874	0.989	0.032	17.5	0.55	0.65	68	
900	1 59	1 2	2.7	2 37	843	1.154	0.037	17.1	0.63	0.79	53	
1000	2 16	1.6	3.1	3 05	819	1.319	0.042	16.7	0.70	0.90	46	67
1100	2 35	2.0	3.4	3 35	796	1.504	0.054	16.5	0.79	1.02	40	
1200	2 55	2.5	3.8	4 07	775	1.698	0.067	16.3	0.89	1.1	36	
1300	3 16	3.2	4.2	4 42	756	1.902	0.079	16.0	0.99	1.3	32	
1400	3 38	3.9	4.5	5 20	741	2.116	0 092	16.0	1.05	1.4	29	
1500	4 00	4.7	4.9	5 59	726	2.331	0.104	15 9	1.1	1.5	26	184
1600	4 24	5.7	5.4	6 30	711	2.565	0.120	15.9	1.3	1.7		
1700	4 49	6.7	5.8	7 13	695	2.808	0.136	15 9	1.4	1.9		
1800	5 15	7.9	6.2	7 56	682	3.063	0.152	15.9	1.6	2.1		
1900	5 42	9.4	6.7	8 31	670	3.334	0.168	16.1	1.6	2.4		
2000	6 10	11.0	7.1	9 14	659	3.601	0.184	16.5	1.7	2.7	..	387
2100	6 39	12.7	7.6	10 00	650	3.877	0.207	16.9	1.8	3.0		
2200	7 09	14.7	8.0	10 48	641	4.181	0.229	17.2	2.0	3.3		
2300	7 40	16.8	8.5	11 39	632	4.487	0.252	17.6	2.2	3.6		
2400	8 12	19.3	9.0	12 31	623	4.804	0.274	18.1	2.4	4.0		
2500	8 46	22.0	9.5	13 24	613	5.140	0 297	18.7	2.5	4.6	..	701

TABLE LXXXVI.—SUMMARY OF TRIALS WITH THE 37-MILLIMETRE REVOLVING CANNON.

Locality and Conditions of Test.	Angle between Line of Fire and Axis of Target.	Distance at Opening Fire.	Distance at Stopping Fire.	Total Time of Fire.	Number of Shots Fired.	Number of Direct Hits.	Rate per Minute.	Percentage of Hits.	REMARKS.
	deg.	yards		m. s.					
Revel, Russia. Gun mounted on the gunboat Strelok. The target was a model of a torpedo boat 71 ft. long by 4 ft. high. Speed, 3 knots.	90	870 650 435 1100 870 650 435 220	650 435 0 870 650 435 220 0	1 00 1 00 2 00 0 45 0 43 0 40 0 34 0 65	16 18 30 10 10 10 10 28	54	16 18 15 13 14 15 18 26	40.9	First Series.—The gun was fired during 1 minute in each cable's length of a continuous run from 4 cables to 0. Second Series.—Continuous fire, from 5 cables to 0, with a record for each cable. The number of hits and per cent. were only ascertained for the entire firing done.
Trongsund, Russia. Gun mounted on the torpedo boat Piskar. The target was the torpedo boat Verona (Bopoha). Speed, 12 knots.	90 90 90 35 35	1100 1100 1100 1100 1100	220 435 220 220 220	2 00 1 30 2 00 2 00 2 00	57 37 44 54 53	23 11 17 4 15	28.5 24 22 27 26.5	40 30 36 7 28	The day was bad for firing, it being a dead calm, so as to cause the smoke to interfere. The gunner had to wash his eyes after each run.
Copenhagen, Denmark. Gun mounted on the gunboat Falster. The target was a model of a torpedo boat 55 ft. long by 4 ft. high. Speed, 9 knots.	45 0 +45 to −45 0 45	1050 1220 1360 810 1050	170 170 1360 136 270	3 00 3 25 6 15 2 10 2 29	60 45 76 30 46	17 30 15 9 9	20 13.2 12.2 13.8 18.5	28.3 66.7 19.7 30.0 19.6	The sea was quite rough for all trials. The third test was a run past the boat. The fourth and fifth tests were at night by the electric light.
Helder, Holland. Gun mounted on the ironclad Guinea. The target was a model of a torpedo boat 71 ft. long by 4 ft. Speed from 10 to 12 knots.	30 45 90	870 1150 1150	0 540 0	2 30 1 30 3 15	46 20 53	28 12 41	18 4 13.3 16.3	61 60 77	The gun was fired by a lieutenant who had not had practice except a series fired just before at a fixed target.

that account. Table LXXXVI. summarises the most important of them so far as rapidity and accuracy are concerned, thus supplementing the trials at Gâvre for penetration.

The summary of the speed of firing and accuracy of aim are contained in the following Table:

TABLE LXXXVII.—*Rate of Firing and Percentage of Hits with 37-Millimetre Gun at Different Trials.*

Trials.	Rate per Minute.	Per Cent. of Hits.
Revel	15.6	40.9
Trongound	25.6	33.5
Copenhagen	15.5	32.9
Helder	16.0	
Portsmouth	15.0	45.7
Average .. .	17.5	38.2

THE HOELLENTHAL RACK RAILWAY.

(*Continued from page* 141.)

Locomotives.—The locomotives are built to run over the whole line rack and adhesion sections. They are, as far as the adhesion engine is concerned, of the ordinary German six-coupled outside cylinder tank locomotive type; as can be seen from the perspective view, Fig. 18, which we give on page 154, and which is engraved from a photograph supplied by the builders, the Maschinenbau-Gesellschaft Carlsruhe. The rack gear is quite separate and distinct, having cylinders between the frames, and the whole arrangement is clearly shown by Figs. 19 to 22 forming our two-page engraving this week, and Figs. 23 and 24 on page 155.

The principal dimensions of the locomotive are:

		mm.	in.
Diameter of adhesion cylinders ...		356	=14.02
Stroke ,, ,, ...		550	=21.66
Diameter of rack ,, ...		315	=12.40
Stroke ,, ,, ...		500	=19.69
Number of coupled axles ...	3		
Diameter of wheels on tread ...		1080	=42.5
Number of rack pinions ...	2		
,, teeth in pinion ...	19		
Pitch of teeth ,, ...		100	= 3.94
Diameter of pitch circle		604.8	=23.81
Distance from centre to centre of pinion shafts		1250	=49.1
Total length of motion lever between crosshead (rack engine) and crank ends		920	=36.22
From fulcrum to crosshead end of lever		560	=22.05
From fulcrum to crank end of lever		360	=14.17
Steam pressure		10 atmos.	=147 lb.
Heating surface of firebox		6.6 sq. m.	=71 sq. ft.
,, ,, tubes		78.0 ,,	=846 ,,
,, ,, total		84.6 ,,	=910.6,,
Grate area		1.37 ,,	= 14.7,,
Centre of leading to centre of crank axle		2130 mm.	= 83.8 in.
Centre of crank to centre of trailing axle		1370 ,,	= 53.9 ,,
Total wheel base		3500 ,,	=137.8 ,,
Length of engine over buffer beams		7680 mm.	=302.4 in.
,, ,, buffers ...		8980 ,,	=353.6 ,,
Capacity of water tank		870 gals.	
,, coal bunkers		1.5 tons	
Weight of engine empty		34.3 ,,	
,, ,, in working order		42.4 ,,	

The engine is able to take a train of 100 tons, exclusive of its own weight, up an incline of 1 in 40, on a curve of 240 m. radius at a speed of 20 km. per hour, and on the rack section incline of 1 in 18.8 at a speed of 10 km. per hour; in the latter case with both rack and adhesion cylinders working. The adhesion cylinders, motion work, and valve gear (Allan's) are of the ordinary type and are placed outside the frames. The rack cylinders are between the frames. The pinion gearing is fitted in a special frame quite independent of the main frames. This frame is carried direct on the coupled axles without the intervention of any springs, as the pinion must always remain at a fixed height from the rail. The motion of the crosshead is transmitted to the pinion shaft by means of a lever with unequal—560 mm. and 360 mm.—arms. The longer arm is connected to the crosshead and naturally makes the engine more powerful, as the piston speed is higher than it would be with a direct connection in the ordinary way. The two pinion shafts are coupled together. The teeth of the pinion are made strong enough for one tooth to bear the pressure caused by the whole weight of the train. This can only happen when the engine is entering the rack, and the coupled wheels, owing to frost, snow, &c., are slipping. It is, however, possible that when the engine is on the rack section and the wheels are slipping, that an abnormal strain may be thrown on the tooth that happens to be fully in contact with the rack, although the whole pressure could not come upon it; as when one tooth of one pinion is in this condition, two teeth of the other pinion are in working contact with the rack, though not in the best position. The slipping of the coupled wheels does sometimes take place on the rack sections.

The adhesion and rack engines are fitted with air brakes of a type often used on mountain engines. With this arrangement the smokebox is shut off from connection with the exhaust pipe and the link motion put in backward gear. The cylinder then acts as a pump, draws air through the exhaust pipe, compresses it and forces it into the steam pipe. This air is allowed to escape through a cock and an arrangement fitted on the chimney. By means of this cock the air pressure—or, in other words, the retarding pressure on the piston—can be regulated. Water is injected into the exhaust pipe and enters the cylinder with the air. This water absorbs the heat generated by the air compression, and prevents the cylinder and piston from becoming too hot. It is turned into steam and escapes with the air through the steam pipe. This brake allows of the speed being regulated to a nicety, and that without undue wear of tyres and rails. An ordinary screw brake is fitted to the driving wheels. On the pinion shaft are discs with V grooves, on which brake blocks with similar V grooves are fitted, which can be applied independently of the coupled wheels. Besides these the carriages are fitted with the Schmidt brake.

(*To be continued.*)

THE INSTITUTION OF MECHANICAL ENGINEERS.

On the evenings of Thursday and Friday of last week, January 29th and 30th, the forty-fourth annual general meeting of the Institution of Mechanical Engineers was held at the Institution of Civil Engineers, the theatre having been lent by the Council of the latter society for the purpose.

The following two papers were down for reading: "On Some Different Forms of Gas Furnaces," by Mr. Bernard Dawson, of Malvern. "On the Mechanical Treatment of Moulding Sand," by Mr. William Bagshaw, of Batley. The "Fourth Report of the Research Committee on Friction" was also on the agenda; the subject treated of being "Experiments on the Friction of a Pivot Bearing." There was, however, no time for the reading of this at the meeting, and it was therefore adjourned.

On the members assembling on Thursday, Mr. Joseph Tomlinson, the President, occupied the chair, and the reading of the annual

REPORT OF THE COUNCIL

was proceeded with. From this it appears that at the end of last year the number of names of with a normal resistance, two interrupters for the principal machine circuit, and one ampèremeter. On each of the feeder circuits are two interrupters, one for each pole, and an ampèremeter which measures the strength of the current that traverses the feeder; in addition each of these circuits are supplied with a voltmeter which is in connection with the control wire, which abuts on the end of the feeder; this voltmeter indicates permanently the difference of potential in the box supplied from the feeder. These last-named conductors are calculated for a maximum loss of 14 per cent.; the secondary conductors for a loss of 1 per cent. The intermediate conductors are of a less section, it being assumed that a part of the current is taken at 440 volts from the outside conductors, and a part at 220 from the intermediate conductors. The five-conductor system lends itself admirably for all uses of the electric current; it allows incandescence lamps to be arranged singly, and arc lamps in pairs or in groups of four or eight, while at the same time accumulators or motors can be furnished with current at a potential that is not at all dangerous; it also facilitates the transport of electricity over considerable distances without an exaggerated first cost for conductors.

THE SOCIETE D'ECLAIRAGE ET DE FORCE PAR L'ELECTRICITE.

We may now pass on to consider the sector occupied by this company, and which extends from the Grand Boulevards to the Fortifications, including a very important area. We may first describe the system of canalisation adopted.

The conductors of this company are laid wholly underground like those distributed over the other sectors of Paris, all of the concessions having been granted on this express condition. The canalisation consists, as regards its general features, of bare cables or of bands of cross-sections varying from 100 to 1000 square millimetres, supported upon insulators of a special type, placed in cement channels 12 centimetres deep and 30 centimetres wide; these channels are laid parallel to the houses. The cables, bands, and wires, in fact all the conductors, have been manufactured by MM. Lazare, Weiller, and Co.; the cables are of silicious bronze of 98 per cent. conductivity, and having a tensile strength of 46 kilogrammes per millimetre (25.40 tons per square inch); the bands are of copper of high conductivity. The channels are covered with cement slabs, usually at a depth of 30 centimetres below the level of the pavement. The distance from the centre of the channel to the front of the houses, varies with the local rules in the different arrondissements; the range is from about 18 in. to 4 ft. 6 in. In all cases a clear width is left between the channel and the houses for the Municipality to lay pipes, &c. The levels are always low enough to be clear of surface construction, and the sewers are traversed by troughs built of I iron as indicated in the views Figs. 42 and 43. Except in very few cases it was not possible to cross the streets by open trench, and the conductors are therefore taken across in tunnels driven without interfering with the surface, and at depths varying from 6 ft. to 35 ft. according to the position of sewers, &c. Access to these tunnels is provided by shafts from 60 to 80 centimetres (23.60 in. to 31.50 in.) square, and closed at the surface by asphalted cast-iron plates of the regulation Paris pattern. At frequent intervals, and especially when any change in direction occurs, manholes are provided 20 in. square; these are closed in the same way as the shafts. So far as was possible, the conditions involved in the establishment of a first-class overhead line have been followed, but the points of support are, of course, much closer together; at intervals of 3 metres the cables are strained to porcelain insulators of a special type; these are cemented to galvanised iron standards 17 centimetres long, with melted sulphur (see Figs. 44 and 45). These rods are screwed at each end (Fig. 48), and the lower end is also cemented by sulphur into a cast-iron base built into the channel. Where only two or four cables are to be dealt with, these base-pieces are cast in one with a connecting rib, and they are laid upon a soleplate 27.5 in. wide. Where a larger number of cables have to be provided for, the bases are grouped upon a bedplate 7 ft. wide. The arrangements are shown in Figs. 46 and 47, and 49 to 51. The porcelain insulators are of a simple bell pattern with a wide throat near the top to receive the cable; they have also two side projections for the iron stirrups that keep the cable in place, as seen in Figs. 52 to 54. The control wires are carried by small porcelain insulators made with an inclined groove (Figs. 55 and 56); the standards that support them are screwed into iron straps 2.60 in. wide and .39 in. thick; these straps are bolted to the vertical sides of the channels (see Figs. 57 and 58). In the galleries the cables and the control wires are hung to the sides on porcelain insulators of the same types as those described above, but carried on iron brackets. The positive cables are all placed on one side of the gallery, so far as possible on the side near the houses, and the negative cables are placed on the other side. Fig. 59 shows this arrangement. Some galleries, such as that in the Rue de Bondy, are too fully occupied to render this mode possible; in such cases the brackets carrying the insulators are cemented into the roof of the gallery, the distance between the cables being never less than 25 centimetres (see Fig. 60). In some parts of the system where the available space is very restricted, the company has substituted copper bands for cables; these bands vary in thickness from .08 in. to .39 in., and in thickness from 1.38 in. to 4.52 in. wide. These bands are laid in insulators in the manner shown in Figs. 61 to 63; they were made by MM. Lazare, Weiller, and Co., and were delivered in lengths of 4, 6, and 10 metres, and were provided with the necessary fittings by the same firm.

The ends of the cables are joined together by soldered splices made with the greatest care; the bands are connected by iron gripping plates bolted tightly to one another; the copper strips are recessed so that the bolts may lock them in place and prevent all danger of their slipping; the arrangement is shown in Figs. 64 to 66. After the locking plates are fixed, solder is run in so as make the joint quite perfect. Junctions between the strips and the cables are made with sleeves of a special type, in which one portion has a circular socket for the cable, and the other a flat socket for the strip; after the whole has been closely bolted together, solder is run in to fill up all the spaces.

(To be continued.)

MODERN FRENCH ARTILLERY.
No. LV.
HOTCHKISS REVOLVING CANNON—*concluded*.

THE 47-millimetre and 53-millimetre naval guns are more recent than the smaller calibres; while they are, of course, much more formidable weapons their field of usefulness is somewhat limited, by the fact that they are not adapted for land operation, while the weight of the 53-millimetre gun makes it unsuited for boat service. Table LXXXVIII. contains the ballistical data for the 47-millimetre.

TABLE LXXXVIII.—FIRING TABLE FOR THE 47-MILLIMETRE REVOLVER CANNON.

Service Shell.

	Common Shell.	Steel Shell.
Weight of charge	7.7 oz.	7.7 oz.
Mean weight of projectile	2.37 lb.	2.48 lb.
Initial velocity	1484 ft.	1457 ft.

Distance between sights 43.30 in. Angle of jump 12 minutes.

Range.	Elevation.	Drift.	Angle of Fall.	Remaining Velocity.	Marks on Sight Bar.	Drift Marks.	Mean Deviation.			Time of Flight.
							Range.	Drift.	Height.	
yards.	deg.	yards.	deg.	ft.	in.	in.	yards	yards	yards	seconds
100	0 03	0.02	0 08	1379	0.03	.030	13.7	0.10	0.04	0.02
200	0 06	0.12	0 12	1309	0 06	.038	13.7	0.17	0.07	0 4
300	0 13	0.29	0 21	1243	0.16	.046	13.7	0.25	0.11	0.7
400	0 23	0.49	0 33	1180	0 29	.054	13.7	0.33	0.15	1.0
500	0 33	0.69	0 46	1127	0.42	.062	13.7	0.41	0.20	1.3
600	0 43	0 89	1 00	1086	0.55	.070	13.7	0.49	0.26	1 5
700	0 55	1.2	1 16	1046	0.69	.080	13.7	0.57	0.32	1.8
800	1 07	1.6	1 33	1013	0.84	.089	13 7	0.66	0.38	2.1
900	1 20	2.0	1 51	985	1.00	.098	13.7	0.74	0.46	2.4
1000	1 33	2.5	2 10	959	1.17	.108	13.7	0.82	0.53	2.6
1100	1 47	2.9	2 31	934	1.34	.118	13.7	0.90	0.61	2.9
1200	2 01	3.6	2 52	910	1.53	.128	13.7	0.98	0.70	3.2
1300	2 16	4.2	3 15	890	1.72	.139	13.7	1.06	0 79	3.5
1400	2 31	4.8	3 39	871	1.91	.150	13.7	1.14	0.89	3.8
1500	2 48	5.5	4 06	853	2.11	.161	13.7	1.22	0.99	4.1
1600	3 05	6 3	4 33	836	2.32	.172	13.7	1.30	1.10	4.5
1700	3 22	7.2	5 01	821	2.54	.183	13.8	1.38	1.21	4.9
1800	3 40	8.1	5 31	806	2.78	.195	13.8	1.46	1.33	5.3
1900	4 00	9.1	6 04	791	3.02	.208	13.9	1.55	1.45	5 6
2000	4 19	10.2	6 37	777	3.27	.221	13.9	1.64	1.58	6.0
2100	4 39	11.3	7 12	762	3.52	.235	14.0	1.73	1.77	6.4
2200	4 59	12.6	7 48	747	3.78	.250	14 3	1.82	1.86	6 7
2300	5 20	13.9	8 25	733	4.05	.264	14.6	1.91	2.06	7.1
2400	6 42	15.3	9 04	719	4.33	.278	14.9	2 00	2.26	7.5
2500	6 05	16 7	9 45	707	4.61	.293	15.2	2.09	2.47	7.9
2600	6 28	18.4	10 30	695	4.90	.307	15.5	2.18	2.68	8.3
2700	7 52	20.0	11 17	683	5.20	.323	15.8	2.27	2.95	8.7
2800	7 17	21.8	12 07	671	5.52	.338	16.1	2.36	3.25	9.1
2900	7 42	23.8	12 59	659	5.86	.356	16.4	2.45	3.56	9 5
3000	8 08	25.8	13 54	648	6.19	.374	16.8	2.54	3.88	10.0
3100	8 35	27.8		6.7	6.50	.392	17.2	2.63	4.20	10.4
3200	9 03	30.0		624	6.89	.410	17.6	2.72	4.55	10 9
3300	9 31	32.3		612	7.27	.428	18.1	2.81	4.91	11.4
3400	10 01	34.7		600	7.65	.448	18.6	2.90	5.28	11.8
3500	10 31	37.2		590	8.04	.468	19.2	2.99	5.70	12.3
4000	13 12	51.9		542	10 16	.573	22.2	3.44	8.64	14.7

The following is a summary of practice with this gun at Shoeburyness. The first trials of the series were directed against a target 6 ft. by 12 ft., the range being 300 yards; the gun was fired and trained from the shoulder. The target was lined out and valued as follows: Shots planted in a square bull's eye, 12 in. by 24 in., ranked as 5; in a centre, 2 ft. by 4 ft., as 4; an inner, 4 ft. by 8 ft., as 3; the rest of the target was valued at 2. Under these conditions, 11 rounds fired in 45 seconds gave a total value of 29 hits in a possible 55; 19 rounds fired in 60 seconds gave a total value of 57 hits in a possible 85; and 70 rounds fired in 240 seconds gave a total value of 250 hits in a possible 335. In this series the average rate of firing was 17.5 rounds per minute, and the percentage of hits 62. In the second series two targets were fired at alternately; the distance between the targets at right angles to line of fire was 40 ft.; the targets were marked on before and the range was 300 yards. Nineteen rounds fired in one minute gave 18 hits; the values being, left-hand target, 32 in a possible 45; right-hand target, 34 in a possible 50. Afterwards 58 rounds were fired in 3 minutes 12 seconds with 56 hits, of which the left-hand target received 101 in a possible 145, and the right-hand target 115 in a possible 145. In these trials the mean rate of fire was 18.3 shots per minute; the mean value of hits 69 per cent., and the total hits 74 out of 77 shots fired. At a series of trials at Gàvre against three targets with different ranges, the following results were obtained

Length of range	350 yards		570 yards		1000 yards	
Size of target ..	13 ft. by 39 ft.		13 ft. by 39 ft.		13 ft. by 39 ft.	
Kind of firing ..	Deliberate	Rapid	Deliberate	Rapid	Deliberate	Rapid
Number of shots fired	10	30	10	10	10	10
Number of hits	10	26	9	9	9	9
Time of firing ..	58 sec.	1 m. 45 sec.	35 sec.	32 sec.	41 sec.	31 sec.

In subsequent trials the same targets were used; two series were fired, the first consisting of two salvoes of four shots on each target, shifting after each salvo; the second included two salvoes of five shots on each target in the same order.

Number of Series.	Range.	Fired.	Hits.
	yards		
1st Series ...	350	8	7
	570	8	1
	1000	7	1
		23	9
2nd Series ...	350	10	4
	570	10	3
	1000	10	5
		30	12

The particulars of the mechanism are given below.

Kind of Firing.	Elevation.	Rounds Fired.	Time.	Rate per Minute.
	deg.		sec.	
Aiming at horizon	0	10	18	33
,, a point on the beach	10	10	18	33
,, horizon	0	20	45	26
,, ,, ...	0	20	36	30
Without aiming	0	10	85	70

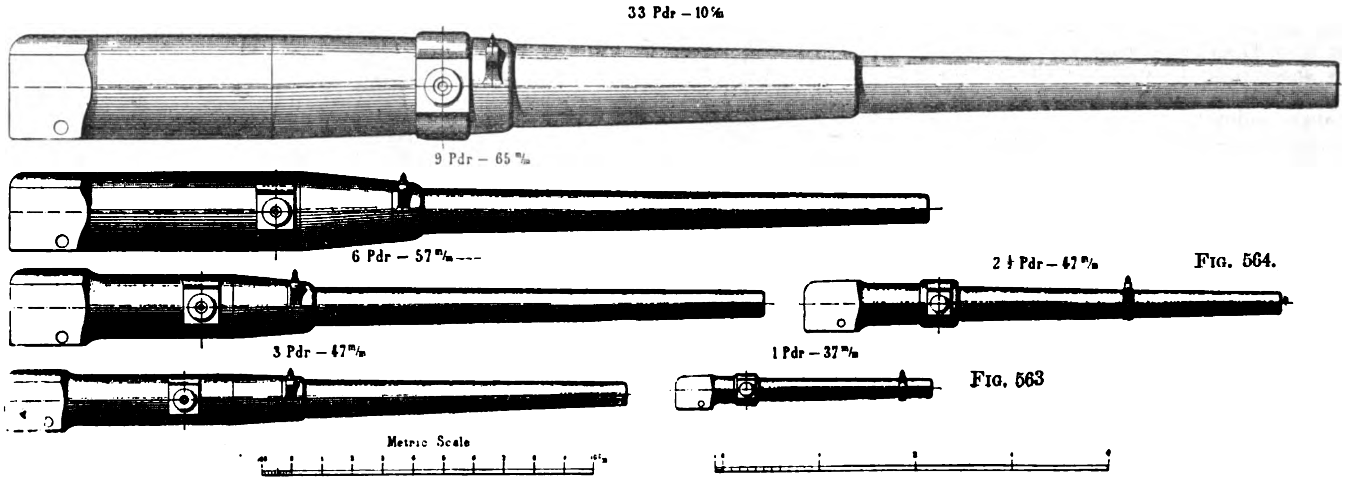


FIG. 568. FIG. 567. FIG. 566. FIG. 565. FIG. 564. FIG. 563.

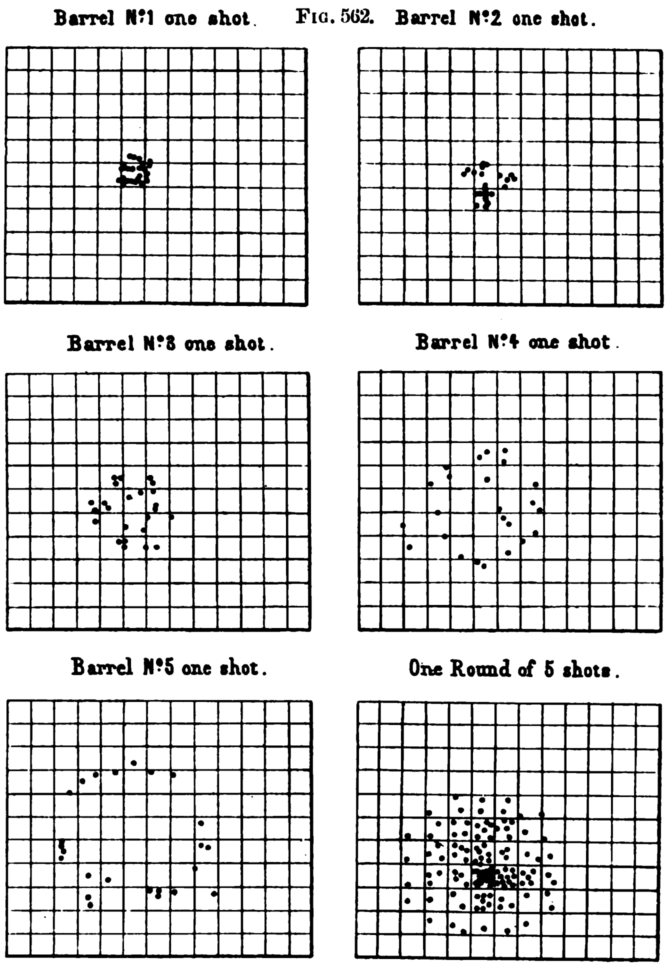


FIG. 562.

The firing data for this gun may be completed by referring to a series of trials carried out against iron plate targets representing a torpedo boat hull. The inclosure, about 30 ft. long, was divided into compartments by six bulkheads $\frac{1}{16}$ in. thick, and a number of rounds of blank, as well as of loaded shell, were fired against it at ranges varying from 200 to 2000 yards, with the result that all the plates were pierced and much broken up by the explosion of the shells; the same damage was inflicted on another target arranged to represent the defence against a deck attack; the great number of fragments of shell found proved the fatal character of the projectile. In other trials of this gun fired against steel and compound plates from 1 in. to 2 in. thick, at a range of 300 yards, the penetration varied from indentations 1 in. deep to complete penetration.

A few words may be said in conclusion of some trials carried out at Sandy Hook by the United States Government with the flank defence gun which has already been described (see *ante*, p. 126). The object of the trial was to ascertain if the gun fulfilled the conditions for which it was constructed, and a programme previously submitted to the Chief of Ordnance was, by his direction, carried out. The principal points were as follows:

That the gun be placed about 10 ft. above the level of the ground.

That targets 50 ft. long, 5 ft. 9 in. high, be placed at intervals of 50 yards, beginning at a point 15 yards in front of the gun, up to a distance of 328 yards.

That firing for accuracy and dispersion be carried on, and the vertical and horizontal targets be plotted in order to ascertain the effectiveness of the gun.

The gun was first mounted on its carriage, the latter resting on the ground, and a single shot was fired from each barrel to ascertain the different dispersions at 15 yards. A complete round was then fired to show the sum of the effects. (The results are shown in Fig. 562.) The gun was then mounted on a stout scaffolding: one target was placed at a distance of 15 yards in front of the piece and six others were arranged at intervals of 50 yards, making the distance from the last target to the muzzle of the gun 315 yards.

A few preliminary rounds were fired to fix the most suitable height for the gun, and finally an elevation of 10 ft. for the lowest barrel was adopted as the proper height. Three series of sixty rounds each were then fired. It is to be observed tha these targets were placed upon the sand and projectiles which passed to one side were free to continue in their divergent paths, while in a ditch they would have been deflected towards the target by the slope or the counterscarp wall. The number of hits would thus have been greatly increased.

The following are the conclusions of the United States Ordnance Board by which these trials were conducted.

"The Hotchkiss revolving cannon is well known now in every service, and its great value as a military weapon admitted. The gun under consideration differs only from the former in the introduction of a new and special rifling for each barrel, in order to give a varying dispersion to canister shot sufficient to cover the length and breadth of the ditch of the work.

"The result of the firing with this special gun clearly proves that guns constructed on this principle would be a most valuable adjunct to the armament of the flank defence of works of the same character as that for which the gun was designed. The short range incident to the special service and the very small space left uncovered by this gun would render its fire very destructive to the *personnel* of an enemy."

HOTCHKISS QUICK-FIRING GUNS.

THE rapid-firing gun, occupying an intermediate place between machine guns and heavier types of ordnance, was the necessary outcome of new conditions of attack and defence, imposed by the construction of the larger torpedo boats, for such guns are essentially adapted for naval purposes, though many of the types are mounted on field carriages for land service. It is not a part of their duty to fire so rapidly as artillery of the Hotchkiss revolving, or of the Nordenfelt types; on the other hand the weight of metal which they throw, as well as their range and penetrating powers, have to be far higher; carried to the highest limit, as at Elswick, or by the Forges et Chantiers, where rapid-firing guns up to 6 in. calibres can be discharged several times a minute, they become really armour-piercing guns, and it is almost certain that in future naval engagements they will play a more important part than the ponderous slow-firing heavy guns. To the Hotchkiss Company must be given the credit for the first introduction of these weapons which are of general adoption in France, and of which the Armstrong rapid-firing guns are only a modification. Their necessary characteristics are: great powers of endurance under severe use, portability, rapidity of fire, relatively high penetrative power and range. In order to attain the very high standard that a compliance with these conditions involves, special care has to be bestowed on the quality of the steel employed, and the tests to which it is subjected are much higher than those imposed

HOTCHKISS RAPID-FIRING GUNS.

FIG. 569. 1-POUNDER RAPID-FIRING GUN ON CONED MOUNT.

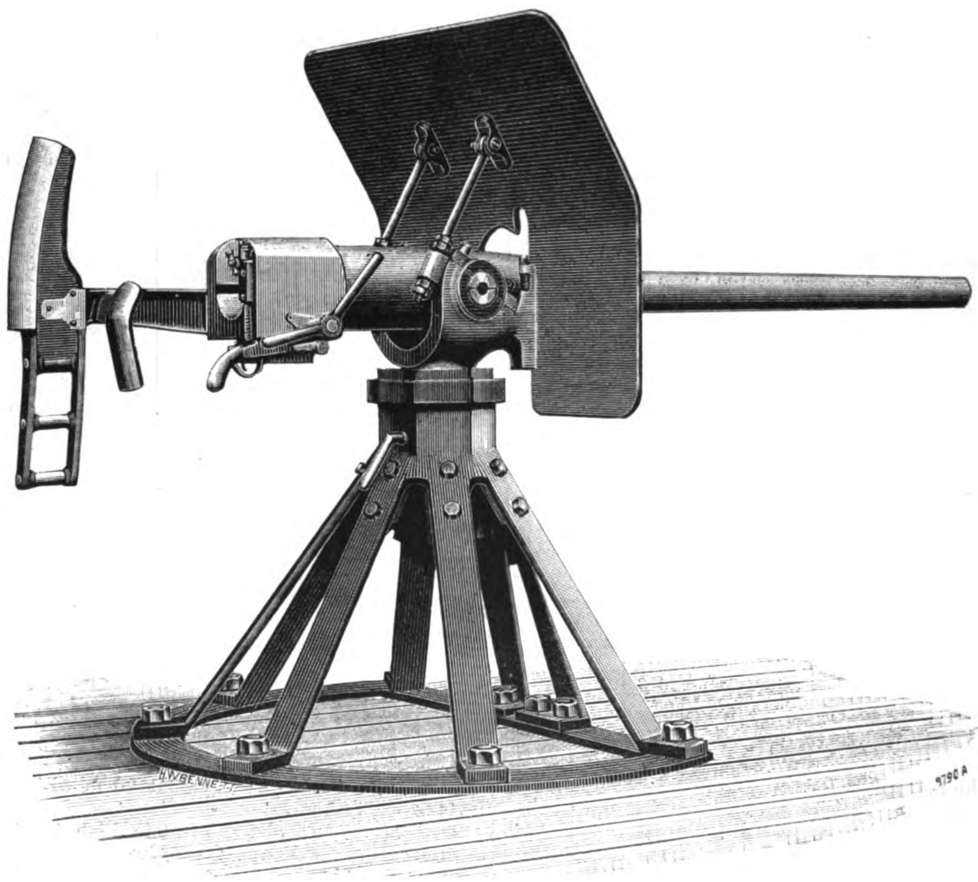


FIG. 570. 6-POUNDER RAPID-FIRING GUN ON CRINOLINE MOUNT.

by the French Government on the steelmakers who supply material for heavy ordnance; such high tests, however, are obtained more easily with the small forgings required for such weapons, than in the great blocks produced for the heavy calibres. As in the treatment of steel for the latter classes, that for rapid-firing guns is carefully tempered and annealed, after which transverse test-pieces are cut from the gun tube, and are made to pass the following test before acceptance:

Minimum limit of elasticity ...	51,000 lb. per sq. in.
,, breaking strength ...	94,000 ,, ,,
,, extension	15 per cent.

As a matter of fact the steel supplied by the makers shows higher qualities than are imposed on the manufacturers, the elastic limit generally reaching 61,000 lb., and the ultimate elasticity ranging from 17 to 21 per cent.

It is interesting to compare these tests with those of the French Government for heavy guns, which are as follows:

Mean elastic limit	45,500 lb. per sq. in.
,, ultimate strength ...	88,200 ,, ,,
,, extension	14 per cent.

A considerable range is allowed, however, in the above figures, amounting to as much as 11,000 lb. for the elastic limit, and 20,000 lb. for the breaking load. The conditions imposed at Woolwich, where it is not considered necessary that the steel should be annealed after tempering, nor that the test-pieces should be cut at right angles to the bore, are somewhat different:

Elastic limit	56,500 lb. to 73,200 lb. per sq. in.
Ultimate strength	81,100 lb. to 105,500 lb. per sq. in.
Extension...	10 per cent.

Thus the steel for Hotchkiss guns occupies an intermediate position between the French and English gun steel so far as elastic limit and breaking strength are concerned, but surpasses both of them in ductility, the English metal by as much as 50 per cent. Considering the hard usage that these guns are built to withstand, the combination, to such a high degree, of strength and elasticity, are quite essential, and are always attainable on account of the small dimensions of the pieces employed. With regard to the strength of the finished gun, the strains to which it is subjected under fire, and its power to resist them, we quote some passages from one of the private publications issued by the company. "In computing the maximum elastic strength of a compound gun, the same general formulæ are used by the artillery departments of England, France, Germany, Russia, Austria, and Italy. In order to determine the relations existing between the elastic strength and the weight of metal in rapid-firing guns, it is proposed to examine the cross-section of a Hotchkiss 6-pounder, near the end of the powder chamber, which is the weakest of the sections submitted to maximum pressures, by applying those generally accepted formulæ, and to compare the results with those obtained from the corresponding section of a rival gun of the same calibre, but of about 10 per cent. less weight; the latter gun having an increased diameter of powder chamber to permit of an increase of the powder charge. The elastic limit is that of Hotchkiss steel, and is assumed the same for the rival gun for the purpose of obtaining a

	Hotchkiss 6-Pounder.	Rival 6-Pounder.
Weight of gun, lb. ...	800	720
Exterior diameter, in. ...	8.3	7.4
Interior, in.	2.7	3.1
Diameter at shrinkage surface, in.	4.9	4.7
Elastic limit of steel, lb.	51,500	51,500

direct comparison. It is found from the formulæ that the maximum elastic strength that can be developed to resist internal pressures would be as follows:

Hotchkiss 6-pounder ...	29 tons per sq. in.
Rival 6-pounder	22 ,, ,,

"In finishing shrinkage surfaces a tolerance of one-thousandth of an inch must be allowed for inaccuracy of work, and this tolerance under such small diameters as are under consideration must be taken into account. Allowing one-thousandth of an inch under gauge, the maximum strains to the elastic limit become:

Hotchkiss 6-pounder ...	27.6 tons per sq. in.
Rival 6-pounder	20.5 ,, ,,

"If these strains be gradually and evenly applied the section will not be strained beyond the elastic limit; but powder pressures are neither gradual nor even, so that the extreme pressure permitted in a gun must fall short of the above amount. At Woolwich a limit of approach or margin is fixed at two-thirds of the computed strength. The maximum powder pressures, therefore, to which their section could be submitted, were they of Woolwich make, would be:

Hotchkiss 6-pounder ...	18.4 tons per sq. in.
Rival 6-pounder	13.7 ,, ,,

"In order that the same powder pressure should

MODERN FRENCH ARTILLERY; HOTCHKISS RAPID-FIRING GUNS.

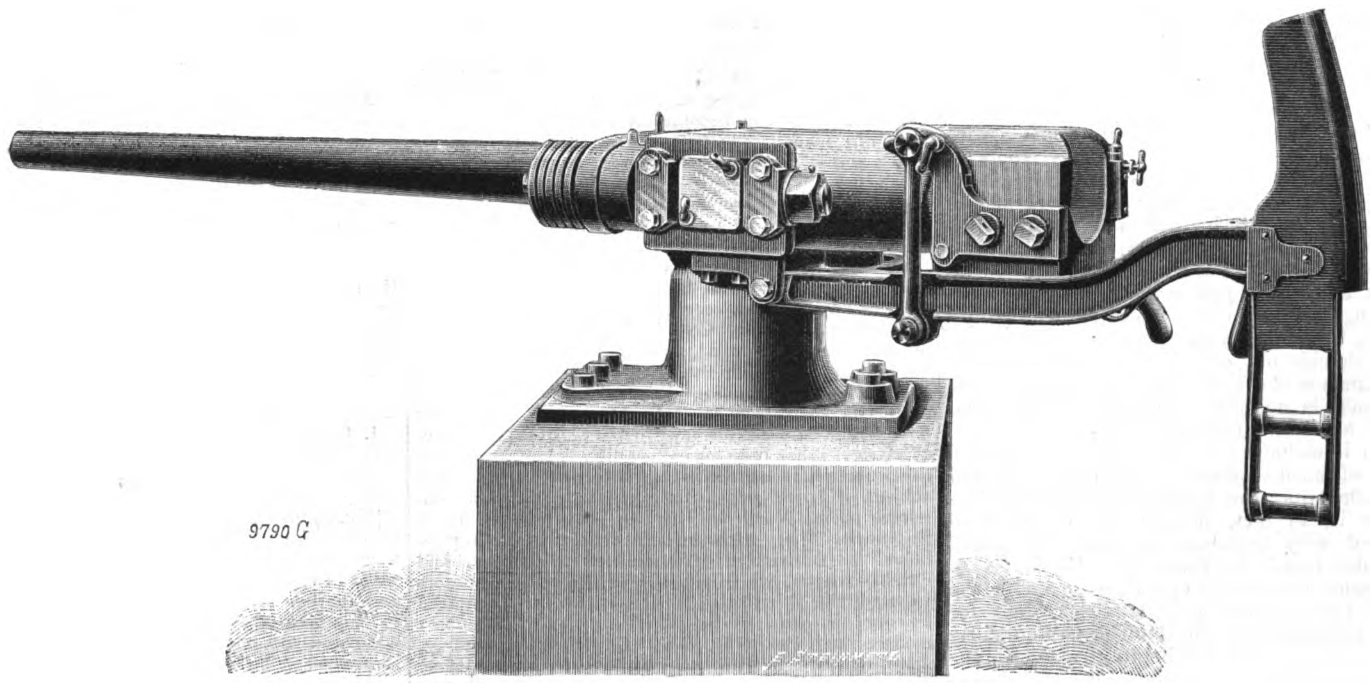


FIG. 571. 3-POUNDER RAPID-FIRING GUN ON EMBRASURE MOUNT.

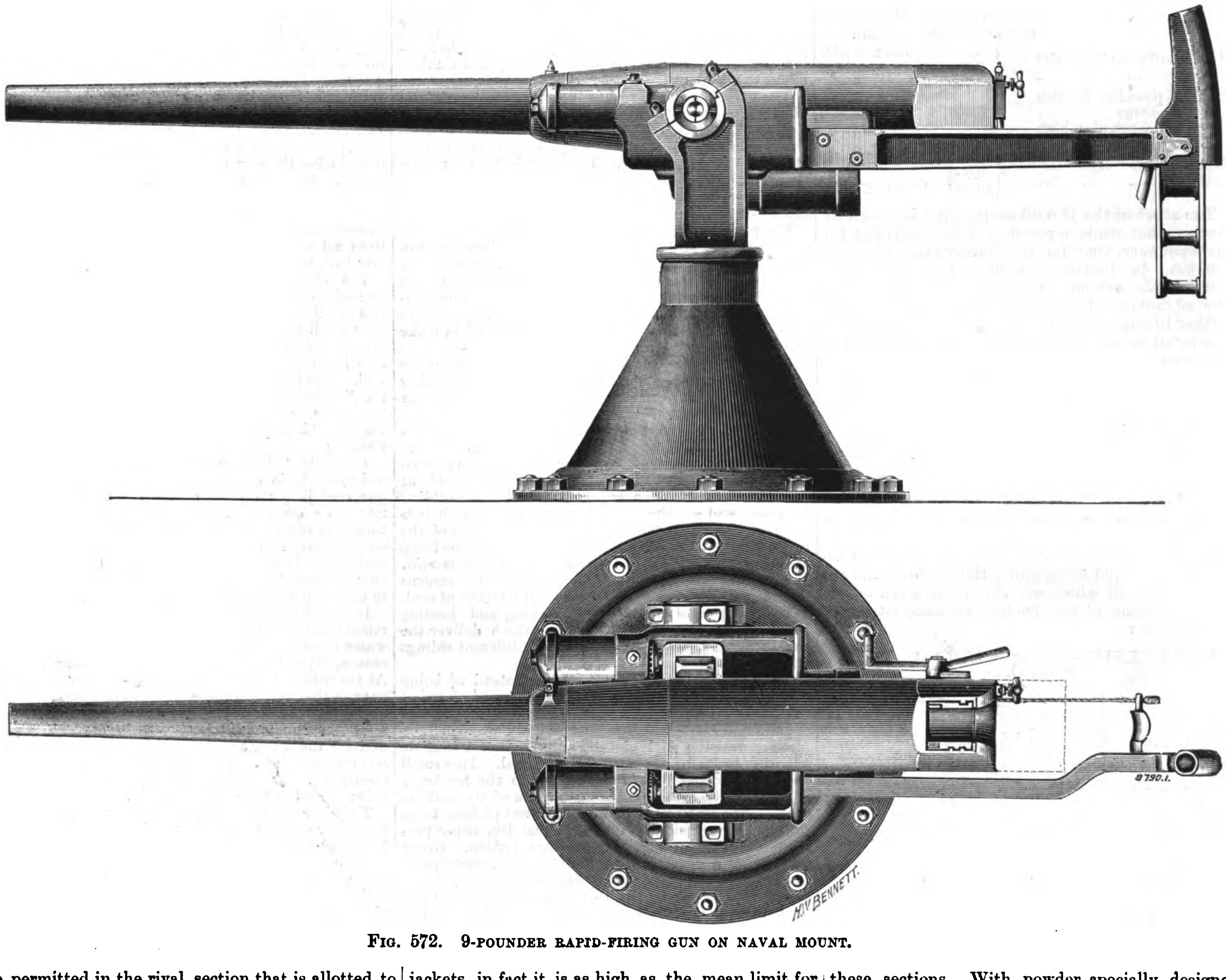


FIG. 572. 9-POUNDER RAPID-FIRING GUN ON NAVAL MOUNT.

be permitted in the rival section that is allotted to the Hotchkiss, it would be necessary to use steel having a minimum elastic limit of 63,000 lb. per square inch. But this is a higher class of steel than is admitted by any Government for tubes and jackets, in fact it is as high as the mean limit for Woolwich steel, which is not annealed after tempering, and has a less elongation than is permitted on the Continent. It now remains to determine what margin of elastic strength actually exists for these sections. With powder specially designed for the gun, the maximum pressure ranged from 13.6 to 15.5 tons per square inch. Therefore, with such powders, the Hotchkiss 6-pounder would not pass the Woolwich limit, whilst the rival guns would. Another point of very important consideration still rests. With certain governments the proof test of a gun prior to reception must show pressures a certain per cent. higher than the pressures obtained with service charges. At Woolwich, for example, the proof test required must be 25 per cent. higher than the pressures obtained with service charges. If it be assumed that the service pressure is 14.5 tons per square inch (and no lower assumption can be made with truth), then those sections must, under a Woolwich proof test, be submitted to powder pressures of 18 tons per square inch; that is the Hotchkiss 6-pounder would still be within the permissible Woolwich allowance, whilst the rival gun would be strained within 2.5 tons of the limit that could be reached under statical pressures."*

A leading feature in the Hotchkiss Company's practice is, therefore, to give ample weight to these guns, which adds not only to the strength, but to the steadiness of the gun, while at the same time this increase is not great enough to hamper manœuvring nor to diminish armament. A marked advantage is claimed for this extra weight, in a reduction of recoil strains upon the mountings and deck attachments; the relatively heavy Hotchkiss 6-pounder is, in fact, mounted on a non-recoil carriage of very moderate weight. The recoil energies developed by firing the Hotchkiss 6-pounder and some other types are given in the following Table, which records two values for energies developed by the Hotchkiss 6-pounder and the rival gun; the first being that due to the English service charge, and the second that due to high charges which are actually used in both guns in other countries.

	Recoil Energy in Foot-Pounds.	Woolwich Guns.
Hotchkiss 6-pounder service charge	5,250	6 cwt. 9-pdr.
	5,350	
	5,750	8 cwt. 9-pdr.
Rival 6-pounder English service charge	5,960	
Hotchkiss 6-pounder high velocity	6,500	
Rival 6-pounder high velocity	6,630	8 cwt. 12-pdr.
	9,830	
	10,500	13 cwt. 25-pdr.

The effect of the Hotchkiss practice is shown by the fact that while a recoil of 3 ft. is allowed for the 9-pounder, that for the former type of gun is less than one-fourth; for the 10-centimetre 33-pounder the amount of recoil is limited to 15 in. The advantage of increased weight in the gun is further illustrated by the respective weights of the non-recoil mounts used for the Hotchkiss and the rival gun.

	Hotchkiss 6-Pounder.	Rival 6-Pounder.
	lb.	lb.
Weight of gun	805	717
,, non-recoil mount...	771	1374
	1576	2091

So that the total weight of the gun and carriage on the latter system is 415 lb. more than that of the former.

The Hotchkiss Ordnance Company manufacture six types of rapid-firing guns, the outlines and respective sizes of which are shown by Figs. 563 to 568, while some of the leading characteristics are given below:

TABLE LXXXIX.—*Particulars of Hotchkiss Rapid-Firing Guns.*

Particulars.		1-Pounder. Fig. 563.	2½-Pounder. Fig. 564.	3-Pounder. Fig. 565.	6-Pounder. Fig. 566.	9-Pounder. Fig. 567.	33-Pounder. Fig. 568.
Calibres ..	in.	1.46	1.85	1.85	2.24	2.56	3.94
Weight ..	lb.	73	264	507	805	1342	3520
Total length ..	in.	33	61	81	98	119.1	173.6
Length of bore	,,	29	55	74	90	111.5	163 7
Travel of shell	cal	18	23	31	35	37	35
Weight ,,	lb.	1.1	2 47	3.32	6	8.8	33
,, of charge	oz.	2.82	7.06	27.53	31 5	54.55	200
Initial velocity	ft.	1319	1457	2002	2002	1935	1970

Figs. 569 to 572 give an idea of the general form of some of the calibres of the Hotchkiss rapid-firing gun. Of these Fig. 569 shows a 1-pounder on a coned mount, and Fig. 570 a 6-pounder on a so-called crinoline stand. Fig. 571 is a 3-pounder quick-firing gun on an embrasure mount, and Fig. 572 is a 9-pounder on a naval carriage.

Further particulars of these different natures and the carriages to which they are fitted will be given in the more detailed description further on.

* "The Hotchkiss System of Rapid-Firing Guns." Printed for private circulation.

COAL SEPARATING AND WASHING PLANT.

WITH the increasing scarcity of good coalbeds in this country, it has become necessary for coalowners and mine managers to pay more attention to improvements and labour-saving appliances in the treatment of the coal when above ground, in order to enable them to profitably work dirty seams of coal, avoiding at the same time all waste. On the other hand the question of having as clean a coal as possible for the production of coke, and clean small coal, such as nuts, &c., for steam purposes, &c., receives no small attention, as buyers pay a very much higher price for coal free from impurities. Coal washing becomes therefore more and more essential, and is looked upon as the only means by which the dirt can be effectively removed. The coal washing question has been approached in recent years from several sides, as the subject of papers read before the mining institutes of this country. Moreover, it has been made (as a sign of how important the question is considered in interested circles) the subject of investigations for a special report of a committee of the North of England Institute of Mining Engineers. Very little on this subject has been published in connection with colliery machinery, and for this reason, we think, it will interest our readers to read the description of the apparatus illustrated on our two-page plate, which is one of the most modern and complete plants for washing, sorting, handling, and loading coal at present in existence. This plant is built on the Luhrig system, which was introduced into this country by Messrs. Simon and Luhrig, of Manchester, whose business has recently been taken over by the Luhrig Coal and Ore Dressing Appliances, Limited, of 32, Victoria-street, Westminster. This is one of several plants erected in Scotland by the above firm for Messrs. Merry and Cuninghame, of Glasgow.

The plant treats the coal as it arrives over bank, and delivers it automatically sorted and washed into railway trucks ready for market. It is operating upon the whole output of three large pits, amounting to about 1500 tons per day. The coal is brought from these pits to the washing plant by means of wire ropes, one of the pits being at a considerable distance from the washery.

The plant consists of a dry separation, of the coal-washing plant proper, and of plant for handling automatically the finest smudge contained in the water used in washing, so as to obviate the necessity for settling ponds, and finally the loading plant. Throughout the whole process the principal aim is to avoid breakage by rough handling of the coal, and to make the action automatic.

With reference to the engravings, which represent an elevation and plan, with sections through the washing plant, and dry separation, the process of treating the coal is as follows:

The hutches, brought by the rope-drives to the platform *a* (Figs. 3, 4, and 5) of the dry separation, are discharged by means of tumblers of an improved construction on to the vibrating screens *b* with about 2 in. round holes. The dry separation has a building for itself, and all the machinery connected with it is driven by a small steam engine independently of the washing plant proper, so that the loading of the lump coal may go on while the washing plant stands still. The bunker into which the dross from the screens falls, is sufficiently large to hold about 100 tons of coal.

The lump coal passes on to picking and loading tables of an improved construction, which deliver the coal into railway wagons standing on different sidings for each class of coal (Figs. 4 and 5).

These picking and loading tables, instead of being constructed of plates as is usual, are formed of round rods with spaces between so as to allow of the passage of the small coal, which is unavoidably produced by picking out the dirt and by chipping off the shale adhering to lumps of otherwise good coal. This small coal is conveyed back for washing to the bunker *c* (Fig. 3) by the lower returning portion of the picking table. The single links of this improved picking table run on L-iron guides (Figs. 8, 9, and 10), being provided with cast-iron rollers to reduce friction. Every fourth link is fitted with a kind of shoe, principally consisting of a vertical plate extending across the table and about 8 in. high. The delivery end of the table consists of an adjustable arm which can be lowered and lifted so as to prevent the coal falling into the wagons and breaking thereby. Over this adjustable arm the aforementioned shoes also travel and prevent the coal from sliding down the incline of the arm. The larger pieces of shale or stone and intergrown coal are separated by hand on these picking tables. The stones are thrown into shoots and brought to the waste bing in the usual way, whilst the dirty pieces of coal are thrown by shoots to a coal breaker *d* (Figs. 4 and 5), which breaks these pieces up in order to win by the subsequent washing process all the coal adhering to the dirt. These crushed pieces of dirty coal are delivered into the dross bunker. Coal hitherto left underground, or sold as an inferior class, is made by this method into good marketable coal, and millions of tons may thus be added at an almost nominal cost to the available stocks of coal.

An elevator *e* (Figs. 3 and 4) lifts the dross from the bunker to the top floor of the washery building and delivers it here into a revolving sizing drum constructed of perforated steel plates, and consisting of several shells to divide the dross into several sizes, nuts, beans, peas, and dust. A previous proper sizing, as effected by this revolving drum, facilitates greatly the subsequent washing, besides producing several classes of nuts, the larger sizes ranging higher in price than the smaller. The different sizes above $\frac{3}{8}$ in. or $\frac{5}{16}$ in. pass through spouts into separate nut coal jiggers *f* (Figs. 3, 5, and 6). These machines are specially designed to deal effectively with large quantities and with the pieces of coal intergrown with shale. To win all this coal these nut washers separate the several sizes of nuts into three classes.

1. Clean washed nut coal.
2. A coal intergrown with shale or brasses, &c.
3. Clean dirt.

The clean nut and pea coal is delivered over drainers *g* (Fig. 5) into hoppers *h* (Fig. 6) ready to be loaded into wagons. The intergrown product is conveyed by a worm working in front of the jiggers to an elevator at the side of the washing boxes, to be lifted and further broken up by a roller mill *i* (Fig. 6) on the top floor of the building. These rollers are 16 in. wide and 29½ in. in diameter. The broken product is re-washed on one of the nut jiggers, and a clean coal obtained from it. The refuse from these machines is discharged by the elevator *k* (Fig. 5) into a channel leading into the refuse pit. The fine coal under $\frac{5}{16}$ in. size from the revolving screen passes with the overflow water from the nut coal jiggers into a grader *m* (Fig. 3), a series of pyramidally-shaped boxes *m* into which the current of water deposits the coal in different sizes according to its gradually decreasing velocity. These boxes supply, through apertures in the bottoms of the pyramids, the Luhrig fine coal jiggers *n*. These jiggers are provided with felspar beds, of which Mr. Luhrig is the original inventor, introducing them as early as 1867 in his coal-washing plants. The dirt separates in these washers through a bed of felspar to the bottom of the machine, and is from there delivered by spouts into the refuse pit. An elevator *o* (Fig. 5) raises the refuse collecting here from all machines and discharges the drained refuse into tubs to be brought to the waste heap.

The clean coal from all the fine coal jiggers is carried with the overflowing water from these machines to a small draining drum, made of copper sheets with very small holes, which separates the pearl coal from the finest coal. The pearls are lifted by an elevator *p* into large storage hoppers *q* (Figs. 2 and 5) for fine coal. The finest coal from this small drum passes with the dirty water into Luhrig's improved sludge recovery apparatus, which, as already mentioned, forms a very notable improvement in the treatment of coal by washing.

This patent sludge recovery apparatus *r* (Figs. 2, 3, and 6) works in a long pit extending underneath the fine coal jigger floor, and consists in the main of a travelling creeper. It works very slowly, and continuously recovers the finest coal dust as soon as it is settling down. An elevator *s* raises the collected fine coal to the hopper *q* (Fig. 2), where it either may be stored separately, or mixed with the pearls, according to the purpose it is intended to be used.

In this manner all the settling material is at once removed, and the constantly fresh gathering dirty water from the various washing machines can, for that reason, deposit quickly its suspended heavier particles. At the other end of the sludge pit the water is clear enough that the overflow of it into the clear water tank may be used again for washing in the plant with a small supply of fresh water. The centrifugal pump *t* delivers the water through a water pipe system to the several machines. The whole plant is lighted by electricity. The engine and dynamo for that plant being placed in the engine-house *u*.

The above description refers to one of the establishments for coal washing erected by Messrs. Simon and Luhrig (now the Luhrig Coal and Ore Dressing Appliances, Limited). Other plants are working satisfactorily in Fifeshire, Cumberland, Yorkshire, &c., and especially where coking coal has to be washed the results are most notable in the improvement in the quality of the coke.

As may be imagined from the foregoing, one machine alone, or one standard arrangement of machines, will not be suitable for every class of coal, and the plants have always to be designed to meet the special character of the coal and the use it is intended for. Two hundred plants have been erected by Mr. Luhrig in different parts of the world, and not two are exactly alike.

In Yorkshire the Denaby Main Colliery Company, The average variation in level of the lakes is from 18 in. to 24 in. during the year, and the range in evaporation from year to year is also very considerable; thus the evaporation per second on Huron and Michigan, as given in the Table on the previous page, is nearly 67,000 ft., but the figures for another year show nearly 89,000 ft. per second, which would represent a difference of $6\frac{1}{2}$ in. in water level. As a discharge of 10,000 cubic feet a second into the new canal would lower the level of these two lakes by 2.87 in. in a year, it follows that the difference between a year of maximum and one of minimum evaporation, is more than twice as great as would be required for the canal, and even under the most unfavourable conditions, the volume taken from the whole chain of lakes would not lower them an inch. When the variations in level due to different causes—rain, wind, and evaporation being the chief—are taken into consideration, the effect of 10,000 cubic feet a second abstracted would probably not be noticeable. That this would be so is the opinion, after careful investigation, of many eminent American engineers. On the other hand there is a similar unanimity of opinion as to the advantages that would be obtained in the condition of the Mississippi by adding to it a tributary of such importance as the proposed canal.

STATIONARY ENGINE PRACTICE IN AMERICA.—No. IV.

By JAMES B. STANWOOD.

Pistons and their Rods.—The general experience with pistons seems to be that the simplest is the best. At all events, in high-speed engines, none but solid heads with split cast-iron rings sprung into them are used. The split ring is sometimes carried in a "junk" or "chunk" ring with which it can be removed and by which the head can be adjusted centrally to cylinder, as shown in Figs. 64 and 65, on page 208.

In the slower moving, long stroke engines more elaborate forms are employed; the "junk" ring in most cases being retained to carry the packing rings which are always of cast iron; Figs. 66 and 67 show a very popular form, made by rivetting two narrow rings together so that each section laps over a part of its neighbour, the German silver springs, through the brass T bolts, press the rings gently against the cylinder surface. In some cases the junk ring is made very wide, as in Figs. 68 and 69, in which it is as wide as the piston is long; in another case it is abandoned entirely, as shown in Figs. 70 and 71. Usually when split rings are used there are two or more very narrow ones employed; the broad ring is not often found.

Pistons are secured to the rods in a variety of ways. One common method is to shrink or force them on as shown by Figs. 65 and 67, securing them finally by a nut placed inside the "follower" plate. In some cases the rod is screwed into the head, and secured again by a nut. There are very few taper fits, except on tandem engines, as the connection is seldom disturbed because the fastening of the rod to the crosshead can be easily uncoupled.

Rods, therefore, are made of straight steel bars with a good thread chased at the crosshead end, this thread being smaller than the diameter of the rod; the other end is turned to suit the piston fit. The diameters of these rods do not follow any fixed practice. Roughly, three-sixteenths of the cylinder diameter is the diameter in the largest part, though as cylinders increase in size this proportion often is smaller.

Pistons are made long axially; it is not uncommon to have them a quarter of the cylinder diameter in length, in smaller cylinders even more. A long piston, with two or more narrow split rings, makes a good tight fit; these long pistons are cast hollow.

Cylinders.—The cylinders, except for special high grade Corliss compounds, are made without steam jackets; a cylinder with such a jacket is a great rarity. Most cylinders have an iron or wooden lagging, beneath which is a layer of asbestos, mineral wool, or hair felting. The most common form of iron lagging consists of small panels secured to the cylinder by machine screws, as shown in Figs. 72 and 73. In one case the lagging is a solid casting bored out and slipped over the cylinder, as shown in Figs. 74 and 75. Russia iron and sheet metal are now seldom used, as they dent so easily.

Bandwheels and Flywheels.—All wheels are cast solid when 10 ft. or less in diameter; they are cast in halves when larger than 10 ft. and less than 20 ft., and in sections when over 20 ft. The maximum size that the railways can transport determines the dimensions and form of this detail. Fig. 77, on page 209, is a sectional view of a solid wheel, while Figs. 78 and 79, on the same page, indicate how a wheel in halves is constructed. The latter is cast solid and split in twain by steel wedges placed in the mould at the rim lugs; the hub is cored in halves by a flat core about $\frac{3}{4}$ in. thick; this, besides parting the wheel, relieves it of strain in cooling. The splitting wedges shown in Fig. 80 are about $\frac{5}{8}$ in. thick, tapering $\frac{1}{8}$ in. per foot on sides, with a negative taper of $\frac{1}{2}$ in. per foot on the edges. When the wheel is sufficiently cool, but before it is removed from the sand, a "nick" is cut around the rim and the lugs to induce the direction of breakage; the wedges being driven home sever the rim at these places; the "nick" is afterward turned out when wheel is in lathe. The slightly ragged edges of break keep the halves of wheel in position laterally and diametrically, so that rough bolts through cored holes can be used. The two halves are bolted together then turned and bored. The split boss is clamped to the engine shaft upon the key. Wheels as large as 20 ft. in diameter by 48 in. face are made in this manner. Very few can be found of recent construction with joints at hub and rim planed and secured by turned bolts passing through drilled or reamed holes.

Patterns for split wheels in some shops have been so systematised by the construction of an interchangeable series of standard hubs, arms, lugs, rims, &c., that a wheel of any weight, face, or diameter can be made at short notice without special pattern work, unless it be a short section of the rim, that has to be made to fix the weight.

Flywheels usually have a section of the form indicated by Fig. 81. In some heavy wheels links are employed, as shown in Figs. 81 and 82, shrunk on after the wheel is on the shaft; ordinarily these are omitted. The rim is turned where "face" is marked. Securing sections by means of lugs and bolts gives the strongest form of wheel, because the section at the rim is nowhere reduced in area, and the lugs and bolts can be proportioned stronger than the rim. In practice the thickness of lug is made equal to thickness of rim.

Wheels over 20 ft. in diameter are built up in different ways. Figs. 83 and 84 represent one of the most common methods of construction. The hub, bored and faced, consists of two heavy ribbed flanges that clamp the arms; one flange has a projection entering a recess in its mate. The sections of the rim, one for each arm, are first planed at the joints and then are bolted together. The arms being secured to the rim, the inner ends are free and extend in between the flanges of the hub; when the latter is correctly centred to rim, holes are drilled through flanges and arms, one hole at each arm being reamed. Bolts are then fitted, after which the completed wheel slung upon a mandrel is turned on the face. Wheels have been made 30 ft. in diameter by 6 ft. face; they can be machined in this manner by relatively small and inexpensive tools.

Bandwheels and flywheels seldom revolve at a periphery speed exceeding 5280 ft. per minute. Here and there a well-constructed and balanced wheel is run at 6000 ft. per minute. The writer knows of a pair of 17-ft. wheels about 36 in. face each, with double arms, and especially heavy rim lugs and bolts that have a periphery velocity of 7000 ft. per minute. A section of one of these wheels is given in Fig. 85, page 209.

Leather belts are almost universally employed to take off the power; recently there have been a few applications of transmission by means of ropes.

Some belts 6 ft. wide have been made and used. Where extreme width is necessary, a number of narrower belts, side by side, each on its own wheel, are employed, especially where the power is delivered to a number of points. Gearing is out of date. Unless, as in Mr. Corliss's practice, the wheels are absolutely accurate, the revolutions of the engine must necessarily be low, and the reduced piston speed requires large cylinders with greater strains on the "running gear," the cost being too great for the power developed.

WATER IN QUEENSLAND.—Advices from Barcaldine, Queensland, state that a great supply of water has been struck in Coreena No. 2 bore at a depth of 904 ft. The supply is estimated at 2,000,000 gallons per day.

MODERN FRENCH ARTILLERY. No. LVI.

HOTCHKISS QUICK-FIRING GUNS—*continued.*

THE Hotchkiss quick-firing guns of all calibres are made of the same quality of steel, the two smallest sizes consisting of an unjacketted tube, whilst the others are reinforced with one jacket; Figs. 573 to 579, pages 216 and 217, show the contours of two of the larger calibres, Fig. 573 being a section of a 9-pounder gun, and Fig. 578 a similar view of a 10-centimetre 33-pounder gun. In Fig. 573 it will be seen that the trunnions are formed on the jacket, while in the 33-pounder they are forged on a special ring. The bores are all rifled with a right-handed twist, the pitch of which is uniform in the 1-pounder and 3-pounder, and increasing from 0 deg. to 6.30 deg. or 7 deg. in the other natures. The form of breech mechanism is the same in all sizes, except for certain slight modifications, and consists of a sliding block that rises and falls in a vertical opening in the enlarged breech that is formed in one piece with the barrel. Figs. 594 to 602 illustrate the system which has been already described in this series of articles.* The block is rectangular in horizontal section with rounded angles; the front face is vertical, and the rear is slightly inclined. The top of the block is cut away to a curve, corresponding with that of the bore, so that when in its lowest position the enlarged continuation of the bore is free for introducing the cartridge; the back of the breech is cut away as shown in Fig. 595, in such a way that the tapered side of the block takes a firm bearing against two projections in the breech, and the forward part is forced upon the seat of the cartridge chamber, when the gun is ready for firing. The block is raised and lowered by a partial rotation of the lever at the side, which is mounted on a spindle passing through the breech, and terminating in a crank, a boss on the end of which enters a curved groove formed in the block (Figs. 598 and 602). On the other side of

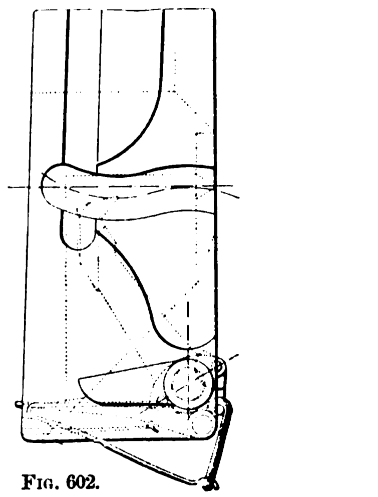


FIG. 602.

the breech a stud passes through and enters a vertical slot in the block to serve as a guide. In addition to these recesses a cam path is also cut in one side of the block—in the 33-pounder there are two such slots for working the extractor; this cam path is shown in dotted lines in Fig. 599, and is of such a form that it imparts a very slight movement to the extractor until the block approaches its lowest position, when it gives the rapid motion required to throw out the empty cartridge. In the front of the block opposite the cartridge chamber, when the gun is in firing position, is a hard steel plate pierced to allow the striker of the hammer to pass.

A broad narrow slot is cut in the middle of the block to receive the hammer (Figs. 598 and 599), which is mounted on a horizontal spindle set in bearings projecting below the block; the firing mechanism is shown in the figures. When the breech-block lever is pulled over to the rear, the stud on the crank passes through that point of the slot in the block which is concentric with the centre of the lever shaft, so that the block does not move, but the cocking-toe (Figs. 583 and 595) descends and cocks the hammer; when the stud, however, passes beyond the concentric path the block begins to fall, and the extractor block slightly recedes. As soon as the block has

* See ENGINEERING, vol. xlix., page 187.

fallen low enough to clear the bore, the rapid action of the extractor commences and the empty cartridge is ejected. The new charge may now be introduced, the rim of the cartridge being pressed home against the extractor hook, and the block is closed by a reverse movement of the lever. When the block is in firing position it is held securely by its own weight pressing on the crank past the centre, by the reaction of the crank and handle in recoil, and by a spring catch. The gun may then be fired by pressing the trigger in the pistol arm. We may now pass on to describe briefly the various characteristics of the different calibres of Hotchkiss rapid-firing guns, and of which it may be mentioned that examples were shown at the Paris Exhibition in the pavilion of the Minister of War.

A. 37-*Millimetre* (1.46-*In.*) *Rapid-Firing Gun.*—This gun is the smallest calibre of the rapid-firing type made by the Hotchkiss Company, and is designed for the smaller torpedo boats, and for open boat service. The same ammunition as that made for the 37-millimetre machine gun, is employed; it is mounted in a fork that can be bolted to the boat's side, or to any other convenient place, and as it can be carried and worked by one man, at a speed of 40 rounds per minute (the weight being about 70 lb.), it is a very effective weapon in the service for which it is designed. Accompanying the gun is a shield to protect the man working it. Figs. 580 to 584 illustrate the construction and the mode of mounting this gun.

TABLE XC.—*Particulars of 37-Millimetre* (1.46-*In.*) *Rapid-Firing Gun with Pivot Mounting.*

Weight of gun	72.6 lb.
Length ,,	33.11 in.
Total length with shoulder piece	45.94 ,,
Length of bore (20 calibres)	29.10 ,,
Weight of pivot and stand	99 lb.
,, shield	99 ,,
,, gun, mountings, and shield	270.6 ,,
Initial velocity of common shell	1319 ft.
Projectiles:	
Weight of common shell	16 oz.
,, steel shell	17.80 ,,
,, mitraille case	20 ,,
Powder charges, weight for:	
Common shell	2.8 ,,
Steel shell	2.8 ,,
Mitraille case	2.12 ,,
Total weight of cartridge:	
Common shell	22 ,,
Steel shell	23.8 ,,
Mitraille case	25.4 ,,
Firing speed, rounds per minute	40

B. 37-*Millimetre Rapid-Firing Gun on Field Carriage.*—The same gun is also adapted to a field carriage, and with this addition it can be used in the double capacity of a boat's gun, and afterwards, if the carriage be taken with a landing party, as a field gun; the carriage is made in a number of parts for easy transport, and can be easily and quickly put together. The limber is very lightly and strongly framed in steel, and carries tin ammunition chests, each holding 60 rounds. The gun, when mounted, is intended to be drawn by hand, though of course it is adapted for horse or mule transport.

TABLE XCI.—*Particulars of 37-Millimetre Rapid-Firing Gun, mounted on Field Carriage.*

Weight of gun with shoulder piece	66 lb.
,, frame	39.6 ,,
Total weight of carriage	316.8 ,,
,, ,, gun and carriage	422.4 ,,
Weight of limber empty	308.0 ,,
,, ,, with 120 rounds	422.4 ,,
Initial velocity, feet per second	1319
Firing speed, rounds per minute	40

C, D. 47 *and* 57-*Millimetre Rapid-Firing Guns and Field Carriages.*—Both these types of guns are provided with carriages for field service, constructed on the non-recoil system that we have already described in detail; the construction of the guns themselves presents no peculiarity differing from the standard details, and the following are their leading particulars:

TABLE XCII.—*Particulars of 47-Millimetre* (1.85-*In.*) *Rapid-Firing Gun Mounted on Field Carriage.*

Weight of gun	209 lb.
Length ,,	52.16 in.
,, of bore (25 calibres)	42.32 ,,
Weight of projectiles:	
Common shell	2.36 lb.
Mitraille case	2.45 ,,
Powder charge	7 oz.
Initial velocity per second	1394.5 ft.
Weight of cartridge:	
Common shell	3.31 lb.
Mitraille case	3.41 ,,
Total length of cartridge	9.25 in.
Weight of carriage	2420 lb.
Height to centre of trunnions	36.61 in.
Diameter of wheels	45.27 ,,
Width between wheels	43.31 ,,
Angle of fire; elevation	+150 deg.
,, ,, depression	− 5 ,,
,, ,, direction	4 ,,
Weight of limber empty	869 lb.
Number of rounds carried	189
Weight of limber loaded	1540 lb.
Total weight of gun and carriage loaded	2530 ,,

TABLE XCIII.—*Particulars of 57-Millimetre* (2.24-*In.*) *Rapid-Firing Gun and Field Carriage.*

Weight of gun	517 lb.
Length ,,	74.61 in.
,, of bore (30 calibres)	67.32 ,,
Weight of projectiles:	
Common shell	5.984 lb.
Shrapnel	5.984 ,,
Mitraille case	6.424 ,,
Powder charge	24 oz.
Initial velocity, feet per second	1394.5
Weight of cartridge	8.86 lb.
,, carriage	1320 ,,
Height of trunnions	42.72 in.
Distance between wheels	59.06 ,,
Diameter of ,,	55.12 ,,
Angle of fire; elevation	+15 deg.
,, ,, depression	− 5 ,,
,, ,, direction	4 ,,
Weight of limber empty	990 lb.
Number of rounds carried	72
Weight of limber loaded	1892 lb.
Total weight of gun and loaded carriage	4323 ,,

E. 47-*Millimetre Gun with Recoil Gun for Naval Service.*—This gun was designed specially for the French navy to fulfil a number of somewhat stringent conditions; it had to combine lightness with considerable penetrative power, so that it could be used with effect against the non-armoured parts of ironclads at moderate ranges, and could keep up a well-directed fire at a rate of twelve rounds a minute, and could be served by three men as a maximum. The trunnions of the gun are forged on the steel jacket, and rest in bearings, the fork of which terminates in a pivot carried within a socket so that a universal movement is obtained, and the gun can be trained in any direction. Mounted with the gun are hydraulic brakes that absorb the recoil, so that its maximum recoil does not exceed 10 centimetres, and by an automatic arrangement the gun is immediately brought back into firing position after each round. Three kinds of ammunition are fired from this gun, common and steel shell, and case shot; the former are fired by percussion fuzes, and the penetration of the steel shell is 10 centimetres.

TABLE XCIV.—*Particulars of 47-Millimetre* (1.85-*In.*) *Naval Gun and Recoil Carriage.*

Gun:	
Weight of gun	484 lb.
Length ,,	80.63 in.
,, bore (40 calibres)	74.06 ,,
Diameter ,,	1.85 ,,
Ammunition:	
Weight of common shell	3.3 lb.
Bursting charge of ,,	2.12 oz.
Weight of steel ,,	3.3 lb.
Bursting charge of ,,	1.76 oz.
Weight of mitraille ,,	3.3 lb.
Number of balls in ,,	40
Powder charge	27.5 oz.
Initial velocity, feet per second	2001
Total length of cartridge (common shell and mitraille case)	20.56 in.
Total length of cartridge, steel shell	20.12 ,,
,, weight of cartridge, shell	6.36 lb.
,, ,, ,, mitraille case	5.60 ,,
Carriage:	
Weight of carriage without shield	638 ,,
,, shield and fittings	297 ,,
Thickness of shield	.63 in.
Total weight of carriage and shield	935 lb.
,, ,, ,, ,, and gun	1419 ,,
Angles of firing; elevation	+ 20 deg.
,, ,, depression	− 25 ,,
,, ,, direction	360 ,,

F, G, H. 57, 65, *and* 75-*Millimetre Rapid-Firing Naval Gun.*—This gun closely resembles the nature referred to above, except that the striking energy of its projectile is almost double. It is fitted on a carriage which limits the range of recoil to 2 centimetres, so that it is well adapted for service on gun-boats. Figs. 585 to 589 illustrate a method of mounting this gun. The brake cylinders are on each side of the trunnions, which are free to slide in guides as shown. The forward pair of cylinders take up the recoil, and the rear pair contain spiral springs which are compressed, and serve to bring the gun back to firing position. Fig. 588 is a section that shows the arrangement of trunnions, trunnion guides, pivot, and socket. Figs. 590 to 593 are sections of the different forms of ammunition employed. The same remarks apply to the 65-millimetre rapid-firing gun, which is also mounted on a non-recoil carriage, and is trained and fired in the same way as the smaller calibres. The 75-millimetre is the heaviest nature that can be trained and fired with a shoulder-piece, and it is for convenience fitted with elevating gear and turning gear; it is a very formidable weapon, firing projectiles of nearly 15 lb. with an initial velocity of over 2000 ft., the penetrating power being equal to 190 millimetres of iron plate.

TABLE XCV.—*Particulars of 57-Millimetre* (2.24-*In.*) *Naval Gun and Pivot Carriage.*

Gun:	
Weight of gun	792 lb.
Diameter of bore	2.24 in.
Length of bore (40 calibres)	89.60 ,,
,, gun	97.64 ,,
Ammunition:	
Common shell (weight of)	5.98 lb.
Bursting charge ,,	3 oz.
Steel shell ,,	5.98 lb.
Bursting charge ,,	4 oz.
Mitraille case ,,	6.42 lb.
Number of balls	80
Weight of charge:	
Common and steel shell	32.8 oz.
Mitraille case	25.7 ,,
Total length of cartridge	18.98 in.
Weight of cartridge	9.72 lb.
Initial velocity, feet per second	1968.5
Mounting:	
Weight of carriage without shield	1012 lb.
,, shield and fittings	347.6 ,,
Thickness of shield	.75 in.
Total weight of mounting	1359.6 lb.
Limiting angle of fire; elevation	+20 deg.
,, ,, depression	−25 ,,
,, ,, direction	360 ,,
Total weight of gun and mounting	2162.6 lb.
Maximum rate of firing, rounds per minute	4.91 in.

THE ELECTRIC MAINS OF PARIS.

(*Continued from page* 180.)

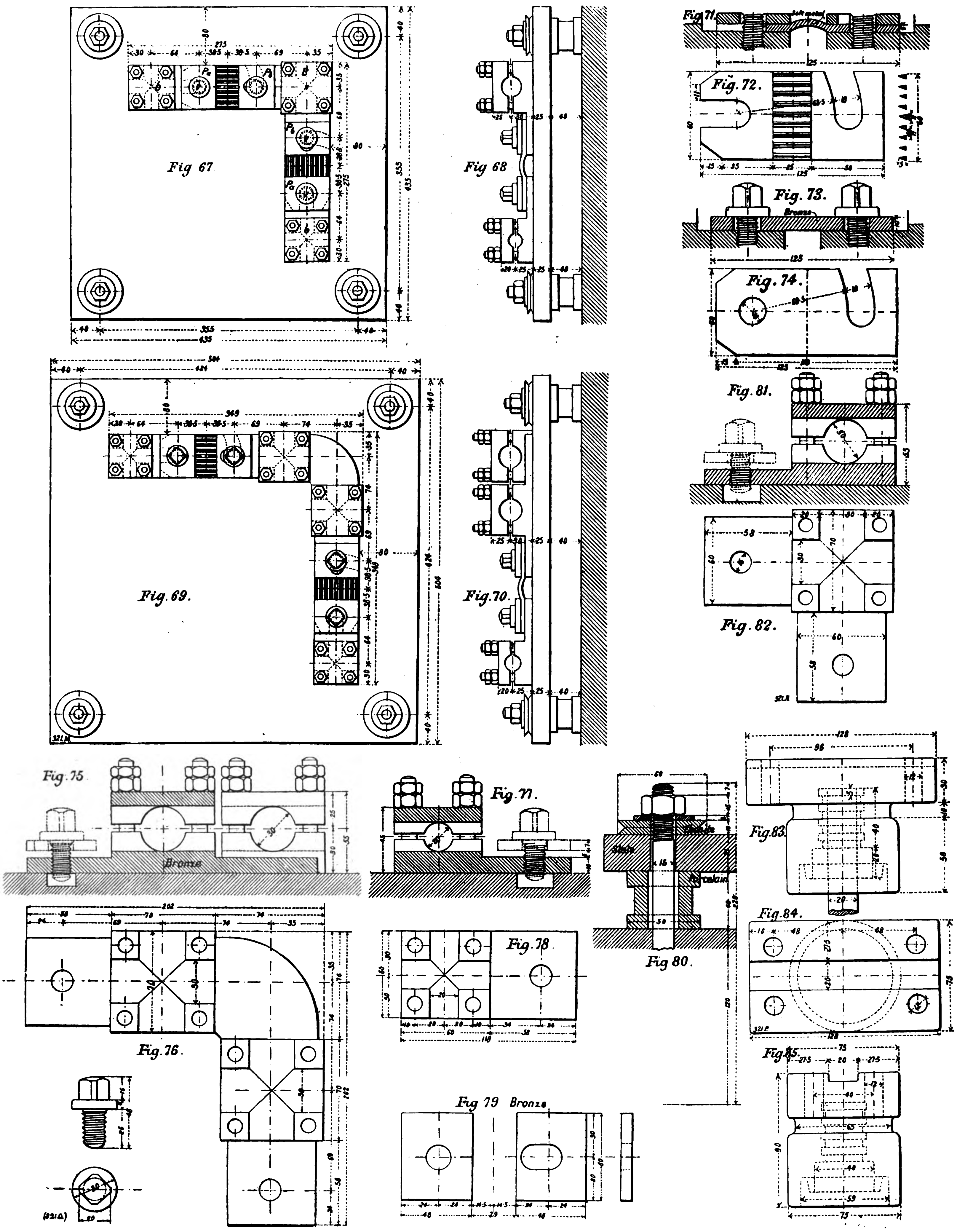
THE SOCIETE D'ECLAIRAGE ET DE FORCE PAR L'ELECTRICITE.

THE feeders were at first connected by means of junction tables made of a slate slab hung to porcelain sleeves. Figs. 67 to 80 show some of these junction tables. It will be seen that in Fig. 67 accommodation is provided for four conductors, while the table in Fig. 68 is only intended for three. The conductors are securely clamped in terminal pieces, having caps secured by four studs (Figs. 69 and 70). The current entering by the conductor at the angle (Fig. 68) may be conducted to either or both of the terminals on the legs of the L table, having in its course to pass through a movable switch (Figs. 71 and 72; Figs. 79 and 80). This switch may be of bronze, like the rest of the fittings (Fig. 80), or it may be of lead or fusible metal (Fig. 79), in which case it acts also as a cut-out. Figs. 73 and 74 are detail views of the corner piece of the L switch (Fig. 67), while Figs. 75 and 76 are similar views of the end pieces. Fig. 77 shows the method of attachment of the slate table by means of bolts passing through a porcelain sleeve, and having a vulcanite washer under the nut. Figs. 81 and 82 are details of the switch shown in Fig. 69. More recently a better insulation was found to be necessary, and the sleeves were replaced by insulators on rods of a type similar to that already described for the main cables. This attachment is shown in Figs. 83 to 85, the shank of the insulator being cylindrical, and the head rectangular. The latter is pierced with four holes for its attachment by screws to the table. A sufficient number of lead safety conductors are introduced into these connecting tables. Such are the general conditions under which the canalisation of the sector lighted by this company have been carried out. The results are stated to be in all respects satisfactory, and the insulation is equal to that realised in overhead lines of the same character.

The Société d'Eclairage et de Force par l'Electricité obtained from the Municipal Council of Paris a concession for the electric lighting of an area extending from the Grand Boulevards to the northern part of the Fortifications, reaching from St. Ouen to the Rue de Caire by the termini of the Northern and Eastern Railway Companies, and including the line of the Boulevards of Magenta, Strasbourg, Bonne-Nouvelle, the Rive Nord, the

THE ELECTRIC MAINS OF PARIS; SOCIÉTÉ D'ECLAIRAGE ET DE FORCE.

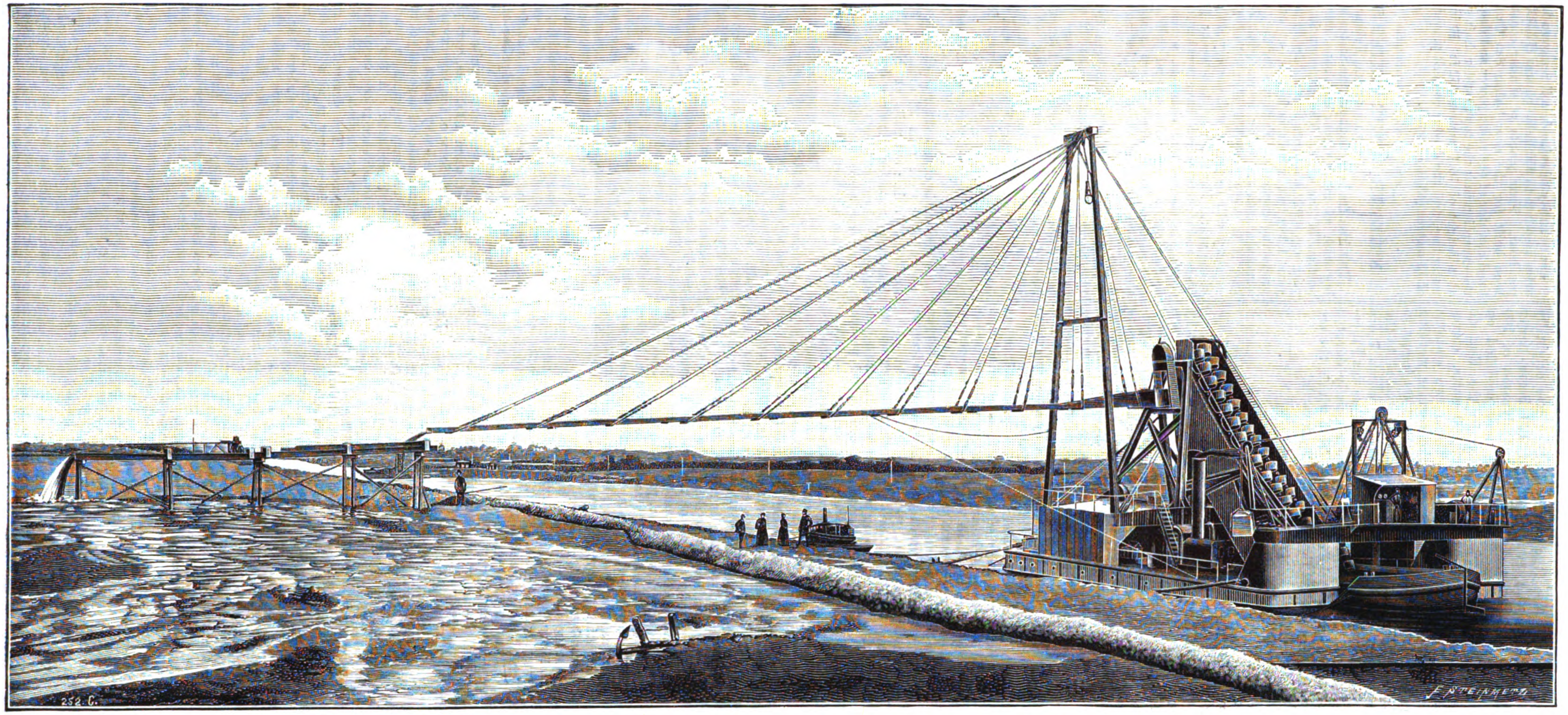
(*For Description, see Page* 211.)



FLOATING ELEVATOR AND SPOIL DISTRIBUTOR FOR THE BALTIC SEA CANAL.

CONSTRUCTED BY MR. A. F. SMULDERS, ENGINEER, UTRECHT, HOLLAND.

(*For Description, see Page* 214.)



Place de la République, and the streets and faubourgs of St. Denis and St. Martin. The first part of their work was carried out in 1889 and comprised the lighting of the boulevards in the zone between the Porte St. Martin and the Place de la République, which forms a part of the boundary of the concession. This lighting included twenty-seven arc lamps of 10 ampères, as a first experiment; these lamps, arranged both at the sides and in the centre of the boulevard, gave a very good idea of the effect it would be possible to obtain in the public lighting of the main streets, an effect greatly superior to that resulting from the use of a single row of lamps in the centre of the roadway, an arrangement that distributes the illumination unequally and leaves large spaces almost in darkness. The mode of distributing the lamps just referred to has been permanently adopted, and their service is assured by a very complete system of mains that have been laid, and a description of which has already been given. The method of distribution may now be referred to, as it possesses several points of interest and appears to guarantee efficient working combined with reasonable economy. It was, of course, a necessary condition that the company should be able to supply current for the simultaneous lighting of incandescence as well as of arc lamps, and for public as well as for private lighting, and a uniform current of 120 volts at the lamp terminals was decided on; this current answering equally well for both classes of lighting if the arc lamps are arranged in pairs in tension. The company claim that by this arrangement a great adaptability to the numerous requirements of consumers is assured, and at the same time a marked economy in the first cost of conductors.

The system of mains over the whole sector is connected at different points in such a way as to form a continuous *réseau*, to which current is furnished by feeders or supply cables connected with the various stations or distributing posts established upon the concession (see Fig. 86). In this sketch, S is a main station, V is a voltmeter, F are feeders, and *f* are potential carriers, while C indicates the general canalisation.

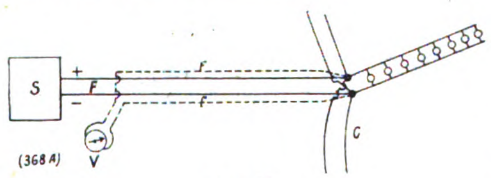


Fig. 86.

The different stations are distributed round the boundaries of the sector in such a way as to be able to aid each other in the event of a breakdown at either one of them. The mains also are so arranged that any part through the whole length can be cut out for repairs or alterations, without affecting the lighting on a distance of more than 100 metres. The mains are always kept charged, and the tension at the points of contact between the feeders and the mains is kept at a certain value by means of the return wires, called potential carriers, running from the points of contact to the commutator table, and by means of the regulators placed at the different distributing stations. The standard electromotive force varies between 121 and 122 volts, according to the charge in the cables. Allowance is made for a loss of 1.5 volts through the mains. The maximum loss in the feeders corresponding to the highest duty and the most economical working, being 12 volts, the current at the various stations can be regulated according to the consumption, between 112 and 124 volts. To insure this the stations are provided with important installations of secondary batteries, which serve as regulators and reservoirs of power, and these, at all periods of heavy demand, discharge the current necessary to supplement that which is being furnished direct from the dynamos working in derivation with the terminals of these accumulators; during the day, when the demand on them is small, the dynamos are used to charge the batteries with the current that they will return again during the evening. Each feeder is led from a general distributing table placed in the station, and so arranged that the current from a variable number of accumulators can be thrown into it. By this means each feeding cable can be kept charged to the standard potential required to maintain the normal current at the points of contact between the feeders and the general canalisation. The regulation can be adjusted to about 0.75 volt, and it will be readily seen that, independently of the security it presents, the electric capacity of a station arranged in this manner is considerably increased. When the installations are completed the capacity of the stations in available watts can be made double that which can be given by the dynamos alone. This point is one of the first importance from an economic point of view; on account, too, of the variable nature of the accumulators and the increase of discharge that can be relied on at any given moment, a continuous supply can be guaranteed even in the event of a breakdown of the machinery. This system of control was carefully tested at the station established by the company at the Paris Exhibition, a 500 horse-power installation that lighted the 30-metre galleries, the central dome, the Galerie Desaix, the restaurant galleries, and some private pavilions.

The stations which the company has erected upon its concession are of two different types. Some of them are transformer stations which receive a high tension current from a primary station at St. Ouen; at these the current is reduced by means of Marcel Desprez transformers to the standard tension of 124 volts at the periods of greatest demand. The others are low-current producing stations, with independent installations of engines, boilers, and dynamos. The large primary station for high tension currents at St. Ouen-sur-Docks can develop an energy of 1500 horse-power electrical. This is distributed between the other transformer stations of the Paris sector, and the suburb where the Société de l'Eclairage et de Force has another lighting concession. This station is laid out in such a manner that it could be very rapidly extended to a power of 10,000 electrical horse-power. The company has, moreover, established two important and complete stations—one of them at 70, Rue de Bondy, and the other at the Rue des Filles-Dieu, by which can now be supplied that part of its concession adjoining the line of the boulevards from the Gare de l'Est to the Rue de Caire, a district where the demands of consumers are the greatest. Some leading particulars of these stations are as follows: That of the Rue de Bondy was originally established for serving the Renaissance, the Porte St. Martin, the Ambigu, Comique, and the Folies Dramatiques theatres; this was completed in September, 1887. Besides 50 tons of accumulators, it comprised two semi-fixed Weyher and Richemond engines of 75 horse-power driving Breguet shunt dynamos, and two high-speed engines each of 70 horse-power by Lecouteux and Garnier; these worked two Thury dynamos at a speed of 375 revolutions. In the building itself there were 8 tons of accumulators, the 50 tons just now referred to being distributed among the various theatres. The total power was 175,000 watts, and the theatres were supplied by separate circuits brought to each of them, and working in derivation from the terminals of the accumulators which were charged during the day, and contained a sufficient supply for the whole evening, in the event of a breakdown at the central station, or of any damage to the overhead wires through which the current was passed. This method of distribution was adopted on account of the impossibility of laying a general system of mains over the district served. At the present time this station has been transformed in such a way as to assure the lighting service both for the theatres and for the other consumers in the manner we have indicated. It now comprises four groups each as follows: One Weyher and Richemond engine of 140 horse-power indicated, driving directly by belts one Desrozier's dynamos at a speed of 300 revolutions and capable of generating 750 ampères at a mean electromotive force of 134 volts, and with an electromotive force varying from 125 to 175 volts during the different periods of charging the accumulators. The batteries of the latter weigh 75 tons, and can discharge in normal working 1000 ampères at 134 volts; the total power of the station amounts to 536,000 watts, corresponding to 14,000 lamps in service. The station in the Rue des Filles-Dieu was originally provided with two motors of 120 horse-power each, driving a Marcel Desprez dynamo of 100 electrical horse-power; it is now modified on the same lines as the station in the Rue de Bondy, and its capacity is 402,000 watts, corresponding to 10,000 lamps. These two stations alone are capable of assuring the regular working of 20,000 lamps, in addition to the 4000 lamps in the theatres; at present they are connected to the system of mains by 13 feeders, of which 7 are for the Rue de Bondy and 6 for the Rue des Filles-Dieu. Six of the feeders are specially devoted to that part of the canalisation from which the arc lamps are taken that light the Boulevards.

(To be continued.)

FLOATING ELEVATOR AND SPOIL DISTRIBUTOR.

We illustrate a floating elevator and spoil distributor constructed by Mr. A. F. Smulders, Utrecht, Holland, for removing dredged material out of barges at the Baltic Sea Canal Works. On page 213 we give a perspective view showing the apparatus at work, and on our two-page plate are given plans, longitudinal and cross-sections, with details. The dredged material is raised out of the launches or barges by means of a double ranged bucket chain to a height of 10.5 metres (34 ft. 5 in.) above the water line, from whence it is pushed to the place of deposition by a heavy stream of water supplied by centrifugal pumps.

The necessary machinery and superstructure are supported on two vessels connected, as shown in Figs. 4 and 5, with cross-girders, a sufficient width being left between each vessel to form a well large enough for a barge to float into, and for the working of the bucket ladder utilised in raising the material from the barges. The girders are braced together and carry the framing for the bucket chains, gears, &c.

The port vessel is provided with a compound engine of 150 indicated horse-power with injection condenser actuating two powerful centrifugal pumps, raising water which enters by a series of holes into the bottom of the shoots underneath the dredged material, carrying the material to the conduit (as indicated on Fig. 4, and in detail on Figs. 6 and 7).

A steel boiler of 80 square metres (860 square feet) heating surface, and 6 atmospheres, (90 lb.) working pressure, supplies steam to the engine. Forward on the deck of the same vessel there is a vertical two-cylinder high-pressure engine of 30 indicated horse-power, which helps to bring the barge to the desired position between the parallel vessels. A horizontal two-cylinder engine of the same power, fitted with reversing gear, placed in the middle of the foremost iron girder, raises and lowers the bucket ladder by the interposition of a strongly framed capstan, as shown on Fig. 5. The gearing throughout is of friction pulleys and worm and wormwheel; it is driven by belts.

In the starboard vessel there is a compound engine of 100 indicated horse-power, with injection condenser, working the bucket chain by means of belts and wheel gearing, as shown on Fig. 2. A marine boiler of 46 square metres (495 square feet) heating surface and 6 atmospheres (90 lb.) working pressure, supplies steam. In this vessel, it may be added, there is a cabin for the crew.

The dimensions of the vessels are as follows: Extreme length, 25 metres (82 ft.); breadth, 4.5 metres (14 ft. 9 in.); depth (moulded), 2.7 metres (6 ft. 6⅜ in.); average draught of water, 1.4 metres (4 ft. 7 in.); space between the ships, 6.55 metres (21 ft. 6 in.). The iron structure connecting the ships is composed of four upright box-form stanchions on both ships, connected at the top by two strong box girders with tie-pieces supporting the main framing. This main framing, also of the "box girder" form, is strengthened with angle irons and braced together at the tops by a platform supporting the gearing of the bucket chains, as shown on Fig. 5. The buckets have a capacity of 160 litres (5.65 cubic feet), and the speed in travel is at the rate of 25 to 30 buckets per minute, so that with both ladders working, 50 to 60 buckets are discharged per minute. The top tumbler shaft is placed at a height of 13 metres (42 ft. 8 in.) above the water line (Fig. 4), and the dredge conduit has a length of 50 metres (164 ft.), Fig. 1. The shooting is done at a height of 8.5 metres (27 ft. 10 in.) above the water line, and the shoot catches the dredged products at a height of 10.5 metres (34 ft. 5 in.) above the water line, the sliding gradient being 4 to 100. The dredge conduit is carried by timberwork resting on two of the upright box-form stanchions.

All cables are of galvanised steel and provided with open twin buckles. The main parts of the apparatus are of steel, and all pieces subject to wear and tear are fitted with bushes so formed that they can be easily replaced.

The quantity of suitable soil removed by these apparatus amounts to 350 cubic metres (12,360 square feet) per hour. Four plants of similar construction have been built for the new Baltic Sea Canal, besides a fixed elevator of the same power and disposition, with the exception that the top tumbler shaft was suspended at a height of 16.1 metres (52 ft. 10 in.) above the water line, and the dredge conduit placed at a distance of 13 metres (43 ft.) from it.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, February 4, 1891.

The iron trade throughout the States is not developing with as much vigour as is usual during the early portion of the year. The consumption of iron last year was 8,922,454 gross tons; shipments of rails last year 1,388,186, which is just about one-half of the producing capacity. Facilities for the turning out of structural iron are being increased at several points, and it is very probable that all of this increased capacity will be pretty well employed during the rest of the year. For the past two weeks prices for both plate and structural iron have weakened a little, excepting in beams and channels, which are held at 63 dols. per net ton. At several points wages have been reduced, but as schedules are established in most iron-making localities there will be no dispute over wages.

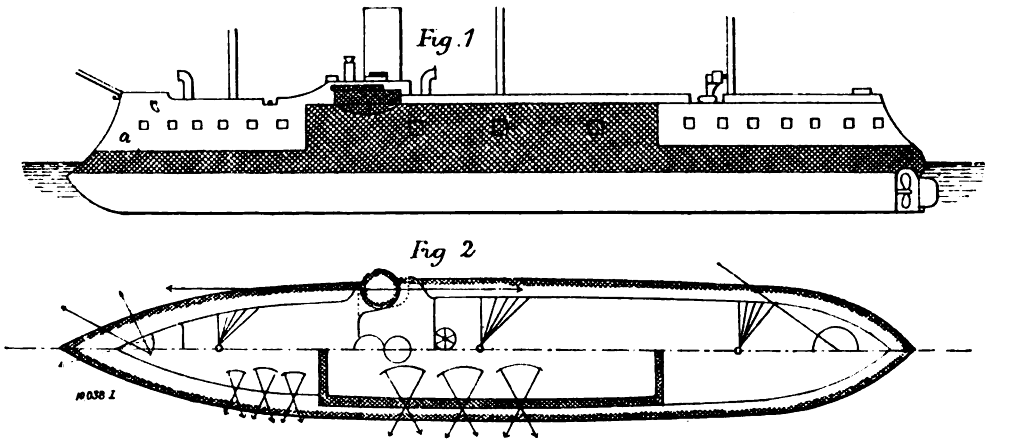
Forge iron is selling in southern iron centres at 10 dols. per ton, and foundry at 12 dols.; freights to northern consuming points range from 4 dols. to 4.50 dols. per ton. Southern ironmakers have not booked much business for a week or two past, as buyers feel that the condition of things is too unsettled. There is a very heavy demand for rods, and large lots have sold within the past few days. In eastern mills prices are 38.50 dols.; contracts are being placed for steel plates at 2.10 dols.; merchant bars are quoted at New York at 1.70 dols.; very little demand is observed for track fastenings. Spikes are 2 dols.; steel rails 28 dols. to 30 dols.; wire nails 2.15 dols.; cut nails at New York 1.80 dols. Hardware manufacturers are doing a good winter's business; there are large stocks of glass in all markets, and several works are still shut down. A general restriction is talked of, unless prices should improve.

PHILADELPHIA, February 11, 1891.

Orders for 100,000 tons of steel rails will probably be placed this week in Pennsylvania mills, of which the Pennsylvania Railroad Company will order about one-half. It is given out that the price will be 30 dols., but upon this point a number of buyers express doubts. The difficulties which have existed for years among railmakers have been eradicated, and a peace has been patched up which makers say will stand the severest test. The Carnegies have the Du Quesne mill, and the two fighting mills at Scranton are now practically under one head, so that there now is peace in camp, and therefore prices are marked up to 30 dols. with the anticipation that they will stay there. It would certainly be an interesting thing to see the railmakers agree at this time and sell 1,500,000 tons of rails this year at an advance of 2 dols. to 3 dols. per ton over what bitter competitive rates would fix. Rail buyers, of course, do not think that these figures are going to hold, but it must be remembered that several years ago the railmen suddenly advanced prices and maintained them for a year or two.

Within the past week or two quite a number of large orders, some of them 1000 tons, were placed for iron and steel plates. Some of the buyers were shipbuilders on the lakes. The heavy orders that we are expecting for structual material have not yet come in. There is an upward tendency in prices in nearly all kinds of iron and steel products. A few furnacemen have endeavoured to advance prices on pig iron because of the falling off in production, but their efforts are not likely to succeed. The demand for merchant iron throughout the country is at a low ebb; reductions have been made at a good many mills through eastern Pennsylvania, elsewhere the schedule prevails. The sheet and pipe mills throughout the country are making better time than bar mills. There is an active demand for old rails and scrap. Car builders are also looking around for supplies for the coming ninety days, but as they expect lower prices their orders are insignificant. The situation in the iron trade is not altogether what manufacturers would like. Mills in some parts of the country are running three-quarter time; there is of course a good deal of confidence expressed in a good season later on, but just at present, after the severe financial stringency, there is more or less unrest that will not disappear until the opening of spring. A good business is being done throughout the interior; railroad managers are somewhat brightened at the prospective decline in freights on account of the short corn crop. Manufacturing enterprises are being pushed along as usual, and productive capacity in

THE CENTRAL BATTERY IRONCLAD "TRIDENT."



every direction is being increased as if there were no danger of over doing. A good many speculative enterprises are before the public, and are being encouraged, such as the booming of manufacturing cities in the Southern States. There is more danger to be apprehended from this tendency than any other; if all the enterprises now under consideration were pushed ahead, the markets would be over supplied with manufacturing products. Inexperienced investors are plunging into opportunities to grow rich suddenly, and the movement must expend its force disastrously before the inevitable lessons will be learned. This does not mean that hundreds of excellent enterprises are not being prosecuted in the south, but only that shrewd promoters are falling in the wake of successful schemes, and are inducing tens of thousands to put their money out in the hope of an early and extraordinary return. Advices from all interior points in the south show that manufacturing enterprise is stimulated, and is being encouraged with good returns from existing plants.

THE FRENCH NAVY.—No. XI.

THE IRONCLAD "TRIDENT."

THE Trident, which is one of the older French ironclads of the Colbert type, was launched in 1876. She is a wooden ship protected by a belt of iron armour only 8.6 in. in thickness, and with a rectangular central battery inclosed with 6¼ in. iron plates. Built at a time when France had only recently commenced to reconstruct her navy, and was a long way behind this country, both as regards naval construction and the means of producing high-class material for defence and offence, she is at the present time somewhat obsolete as a type, and, possessing neither high speed nor great defensive qualities, cannot be ranked as a formidable antagonist. The armament she carries is, however, a very heavy one, including no less than six 10.6 in. guns and ten 9.45 in. A part of the heavy armament is carried in the barbette turrets above the central battery. The following Table contains the leading particulars of this ship:

Date of launch	1876
Material	Wood and iron
Length	321 ft. 6 in.
Beam	59 „ 6 „
Draught of water aft	29 „ 1 „
Displacement	8456 tons
Engines	5083 HP.
Speed	14.2 knots
Number of screws	1
Coal storage	650 tons
Thickness of armour belt ...	8.66 in.
„ „ on batteries	6.29 „
„ deck...	.43 „
Armament:	
27-cent. (10.63-in.) gun, number	8
24 „ (9.45 in.)...	2
14 „ (5.51 „)...	6
Quick-firing guns...	2
Revolving cannon	14
Number of crew	730

THE AUXILIARY YACHT "PRINCESS ALICE."

THERE was successfully launched from the historic ways of Blackwall Yard, whence so many good ships have slid into the Thames in days past, a vessel which in beauty of design will bear comparison with any that have gone before. This is the Prince of Monaco's new yacht, christened on the occasion, the Princess Alice.

It will doubtless surprise many persons to hear that the illustrious owner of this new vessel is an enthusiastic seeker after scientific truth in the field of marine zoology. He has won fame in certain select circles as the designer of various trawls, dredges, and other devices designed specially for bringing up from great depths, marine fauna, and for determining the physical conditions under which they exist. Hitherto his serene highness has pursued these praiseworthy investigations by the aid of a schooner yacht, the Hirondelle; but experience has taught him that steam is necessary in order to get the best results. The consequence has been that Messrs. R. and H. Green have been intrusted with the contract for building the vessel we are about to describe, whilst Messrs. John Penn and Son will provide the machinery.

The vessel is of composite build, the framing being of steel, and the planking of teak. The following are the leading dimensions:

Length on load water line	168 ft.
„ between perpendiculars ...	170 „
Breadth (extreme)	27 „
Depth moulded...	16 ft. 9 in.
Draught (mean)	12 „ 9 „
Tonnage (Thames rule)	555
Indicated horse-power	350

The adoption of a wooden skin in preference to steel was made, as the composite form of construction is the best adapted for a steam and sailing yacht for cruising purposes. If the details of construction be properly worked out the necessary strength and rigidity should be obtained solely from the steel framing, and no stress should be borne by the wooden planking. With such a material as teak, there should be no more fear of leakage and bilge water than with a hull made of iron or steel throughout. At the same time the interior space is not encroached upon as it would be with wooden framing. Wood being not so rapid a conductor of heat as iron or steel, the interior of the vessel is not so subject to alteration of temperature, a point of very considerable importance in hot latitudes. Again, a steel ship cannot be coppered, unless she be wood-sheathed—which is expensive and inconvenient —and therefore the bottom becomes foul, unless the vessel be frequently docked, an operation which is often impossible to be undertaken in out-of-the-way parts that ocean-cruising yachts often frequent.

The vessel is properly an auxiliary yacht, and has a spread of more than 12,000 square feet of canvas. The rig is that of a three-masted square topsail schooner. The sails are by Ratsey and Lapthorne, and make a handsome show in the sail plan. The propelling machinery consists of a set of triple-compound engines of the usual description for vessels of this class, and with the 350 indicated horse-power anticipated the estimated speed is 9 knots per hour. There is a Bevis feathering propeller, so that full advantage may be taken of the big sail-spread. There are two boilers, both of which may be used for supplying steam to the main engines. One is, however, much larger than the other, the smaller being intended to be used for generating steam for auxiliary engines when the propelling machinery is not at work, or for manœuvring the yacht at slow speeds. The auxiliary machinery consists of electric light engines, refrigerating machines, fresh water condenser, steam capstan, winches, whips, and other devices for handling trawls, dredgers, &c. The bunkers will carry 80 tons of coal, which at 9 knots will give a radius of action of 3400 knots. There will be two Downton pumps, one of which is for pumping the bilge whilst the other is for washing decks and filling tanks. The vessel is divided into six water-tight compartments, any two of which can be filled without sinking the ship. There is a long deckhouse, 53 ft. long by 11 ft. broad, amidships, the fore part of which is devoted to the chart-room. Aft of this are the galley bakehouse and deck pantry. The owner's cabin comes next, there being a raised glass skylight which gives a view all round the horizon. Abaft, again, is the companion way leading to the main deck. Further on there is a spare cabin, a dark room for photographic purposes, and the deck laboratory. The latter communicates with another laboratory on the deck below by a lift. The rest of the space in the deckhouse is devoted to the room containing the deep-sea sounding machine and the engine-room hatch and companion.

Below, the accommodation is much of the description usual with large yachts of this type, and, doubtless, the upholstery will be on a scale of sufficient magnificence, but on this we cannot become eloquent as we have not the details at our disposal.

We may add that a full description and illustrations of the vessel recently appeared in our contemporary the *Field*, from which some of the above details have been taken.

THE PHYSICAL SOCIETY.

AT the annual general meeting of the Physical Society, February 13, 1891, Professor A. W. Reinold, F.R.S., past-president, in the chair, the reports of the Council and treasurer were read and approved. From the former it appears that there has been a satisfactory increase in the number of members, and in the average attendance at the meetings. During the year a translation of Professor Van der Waal's memoir on "The Continuity of the Liquid and Gaseous States of Matter" has been issued to members, and it is hoped that the translation of Volta's works, now in hand, will be published before the next general meeting.

The Council regret the loss by death of Mr. W. H. Snell and Mr. W. Lant Carpenter, and obituary notices of these late members accompany the report.

The treasurer's statement shows that the financial condition of the Society is very satisfactory, and that the sales of the Society's publications have increased considerably.

A vote of thanks, proposed by Mr. Whipple and seconded by Dr. Gladstone, was unanimously accorded to the Lords of the Committee of Council on Education for the use of the room and apparatus. Dr. Atkinson proposed a vote of thanks to the auditors, Professor Fuller and Dr. Fison, which was seconded by Dr. Thompson and passed unanimously. The proposer, in referring to the satisfactory nature of the accounts, recommended that the publications of the Society should be brought before physicists and other students of physical science, and Dr. Thompson heartily concurred in this recommendation. A third unanimous vote was accorded to the President and officers for their services during the past year, the proposer and seconder being Dr. Waller and Professor Minchin.

The following gentlemen were declared duly elected to form the new Council: President, Professor W. E. Ayrton, F.R.S.; vice-presidents, Dr. E. Atkinson, Walter Baily, M.A., Professor O. J. Lodge, D.Sc., F.R.S., Professor S. P. Thompson, D.Sc.; secretaries, Professor J. Perry, F.R.S., T. H. Blakesley, M.A., M.Inst. C.E.; treasurer, Professor A. W. Rücker, M.A., F.R.S.; demonstrator, C. V. Boys, F.R.S.; other members of Council, Shelford Bidwell, M.A., LL.B., F.R.S., W. H. Coffin, Major-General E. R. Testing, R.E., F.R.S., Professor G. F. Fitzgerald, M.A., F.R.S., Professor J. V. Jones, M.A., Rev. F. J. Smith, M.A., Professor W. Stroud, D.Sc., H. Tomlinson, B.A., F.R.S., G. M. Whipple, D.Sc., James Wimshurst.

The meeting was resolved into an ordinary science meeting, and Messrs. W. Thorp, B.Sc., G. W. Yule, and S. Joyce were elected members of the Society.

A paper "*On the Change in the Absorption Spectrum of Cobalt Glass produced by Heat*," by Sir John Conroy, Bart., M.A., was read by Mr. Blakesley. The absorption spectrum of cobalt glass, when cold, consists of three dark bands in the red, yellow, and green, with a considerable amount of absorption between the first two. When a piece is heated to nearly red heat, the absorption between the first two dark bands diminishes, and the band in the red moves towards the least refrangible end of the spectrum, whilst those in the yellow and green retain their position, but become less distinct. During the heating of the glass the intensity of its colour diminishes, and as the glass cools, its original colour and absorption spectrum returns. Diagrams and numbers showing the character and positions of the bands in hot and cold glass accompany the paper, together with the numbers obtained by Dr. W. J. Russell (Proceedings Royal Society, 32, p. 258) for cold cobalt glass.

In conclusion the author says that these observations and those of Feussner on solutions, show that the absorption spectra of some substances vary with temperature. In solutions this may be due to formation of different hydrates or to partial dissociation, but in a solid like cobalt glass an actual change on its chemical constitution at a temperature considerably below its fusing point does not seem probable.

Dr. Gladstone said it was generally known that heat affects the colouring power of substances, and that in solutions, absorption is greater the higher the temperature. Different solvents sometimes produce effects analogous to heat, for cobalt salt dissolved in water and in alcohol gives pink and blue solutions respectively, and rise of temperature makes the aqueous solution more blue. He concurred with the author as to the causes of the phenomena in liquids, and that the same explanation would not apply to glass.

Professor S. P. Thompson thought Sir John Conroy's results agreed with the experiments which Mr. Ackroyd

MODERN FRENCH ARTILLERY; HOTCHKISS QUICK-FIRING GUNS.

(*For Description, see Page* 210.)

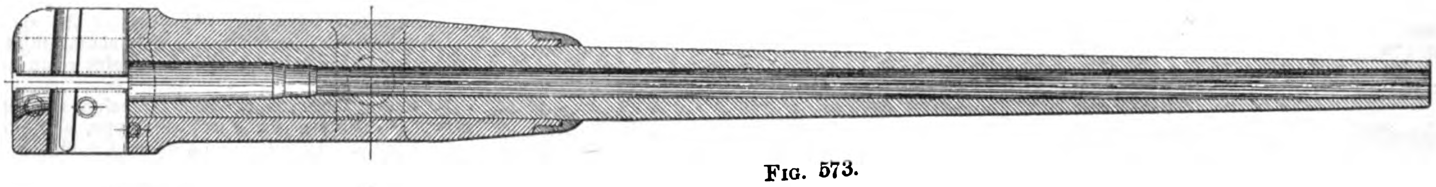


FIG. 573.

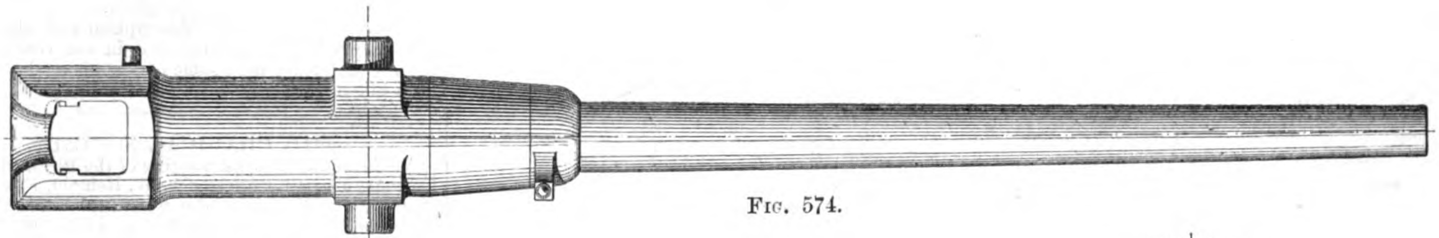


FIG. 574.

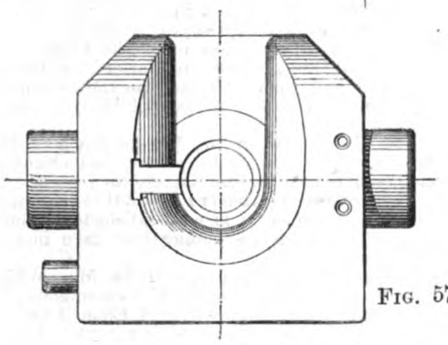


FIG. 575.

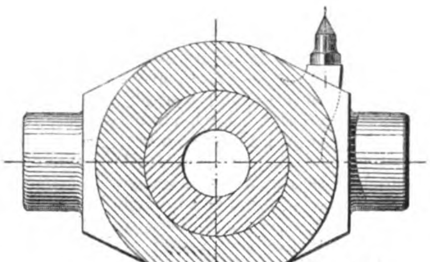


FIG. 576.

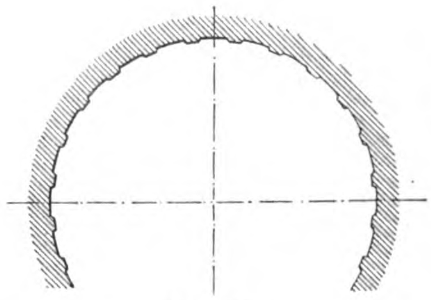
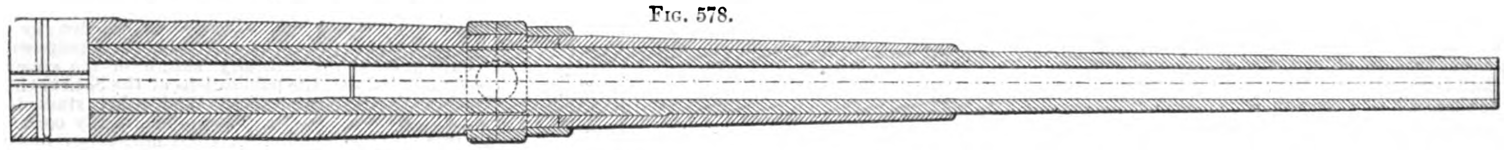


FIG. 577

FIG. 578.



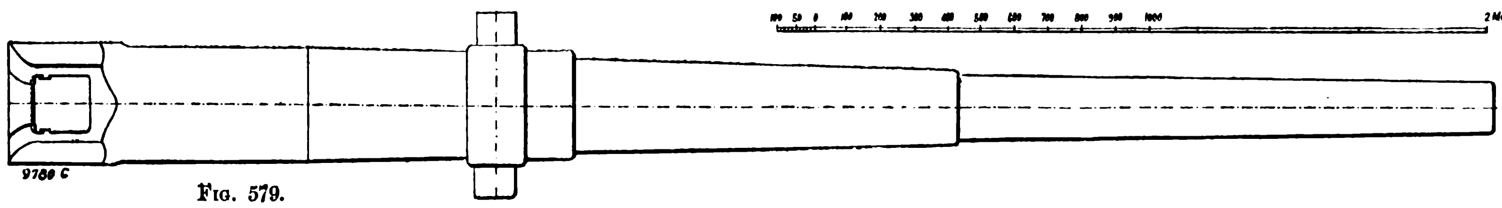


FIG. 579.

STANDARD SECTIONS OF HOTCHKISS QUICK-FIRING GUN.

FIG. 580.

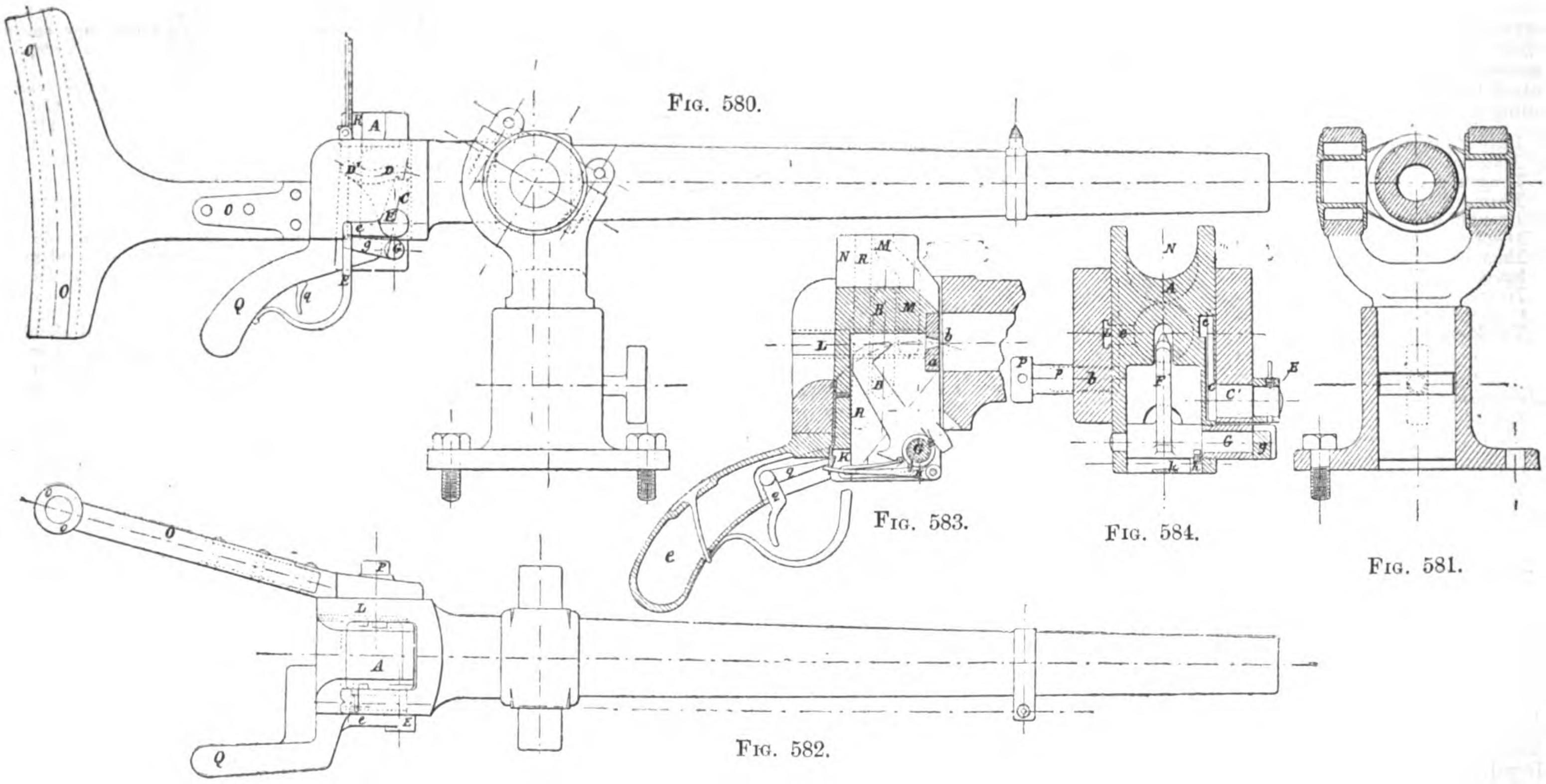


FIG. 583.

FIG. 584.

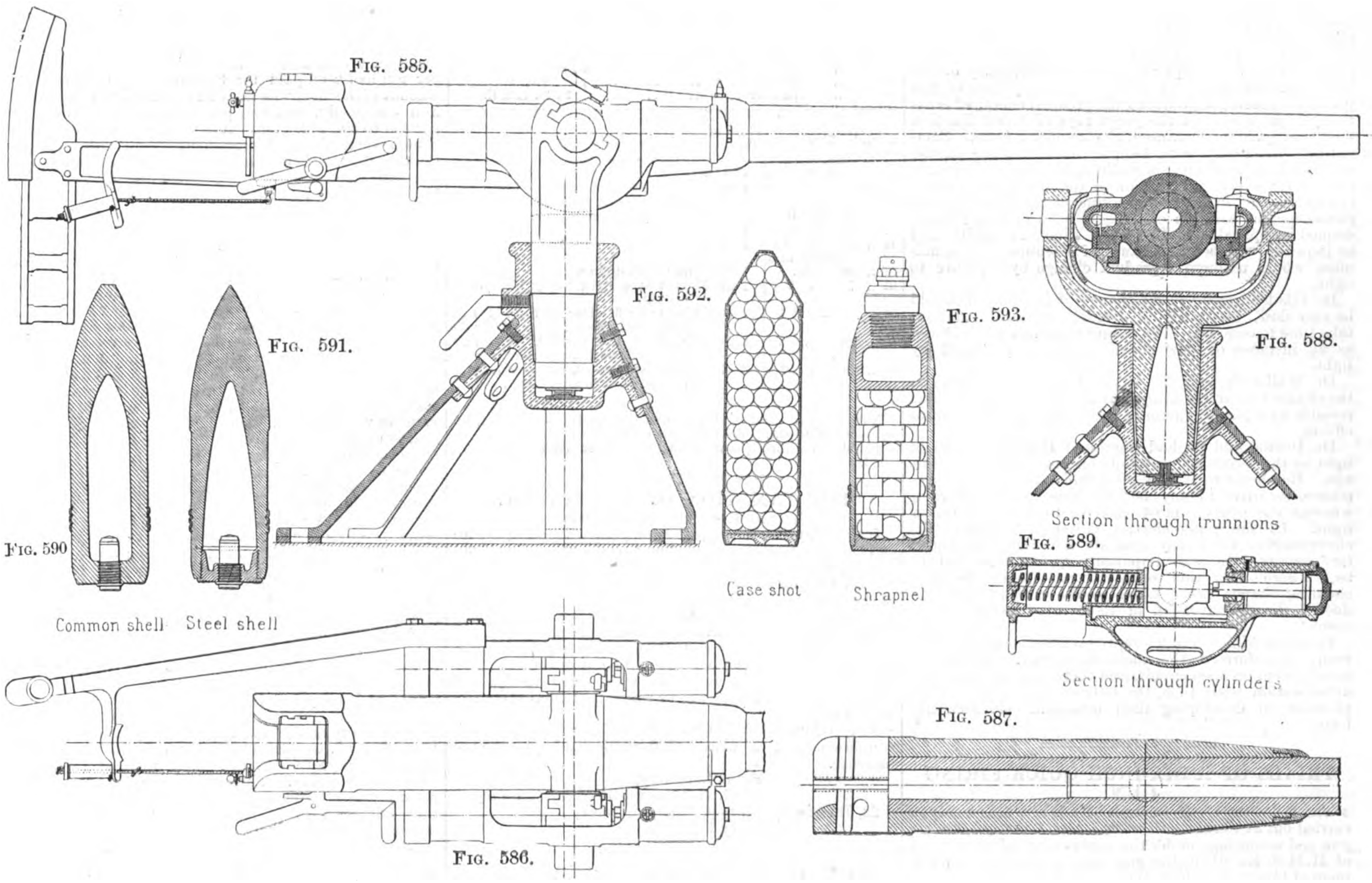
FIG. 581.

FIG. 582.

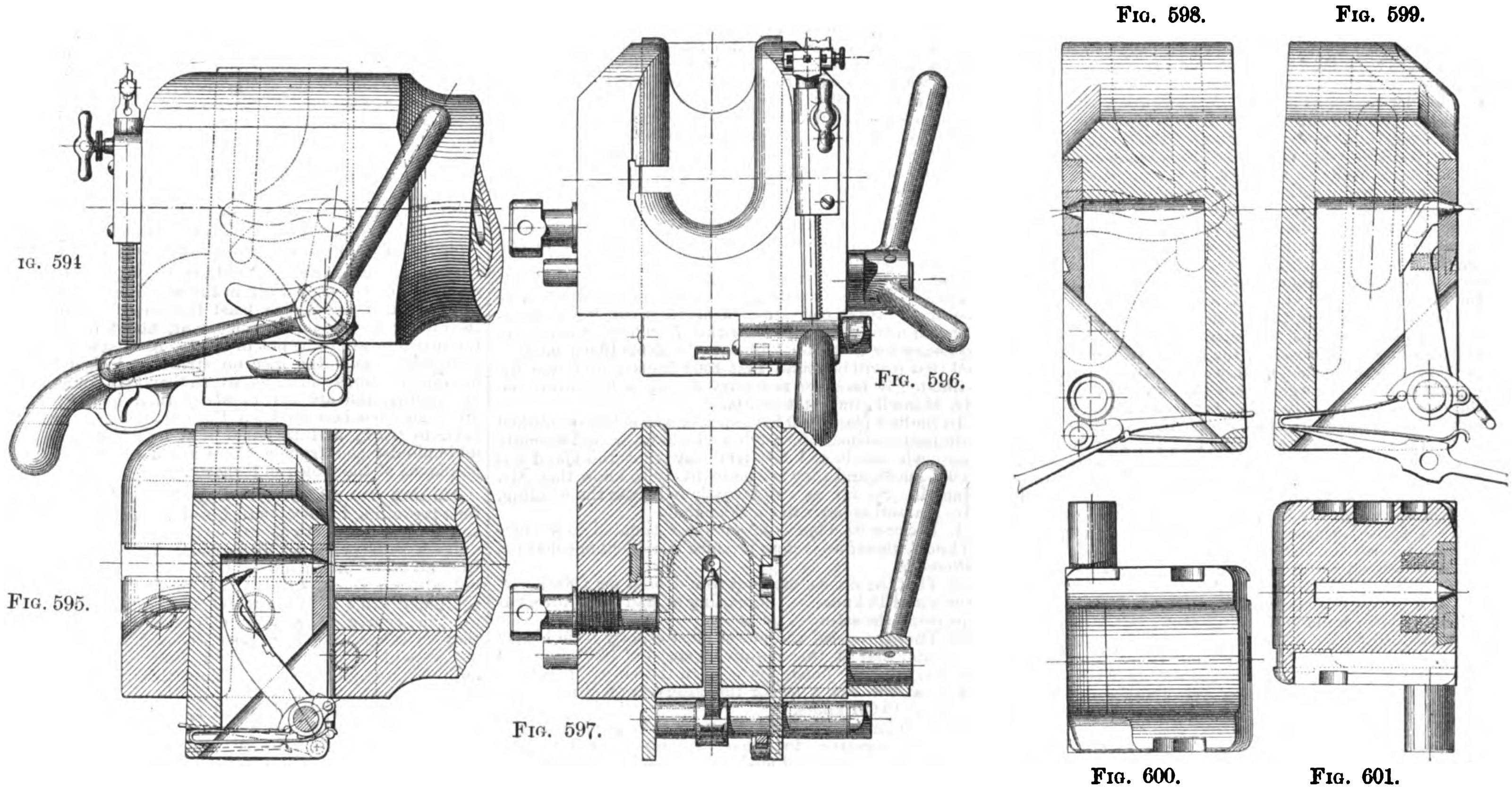
37-MILLIMETRE (1-POUNDER) HOTCHKISS QUICK-FIRING GUN.

MODERN FRENCH ARTILLERY; HOTCHKISS QUICK-FIRING GUNS.

(*For Description, see Page* 210.)



65-MILLIMETRE (9-POUNDER) QUICK-FIRING HOTCHKISS GUN.



BREECH MECHANISM OF HOTCHKISS QUICK-FIRING GUN.

showed before the Society some years ago, when he demonstrated that the colours reflected by opaque bodies, such as porcelain, &c., when heated, tend towards red.

Professor Minchin showed some experiments in illustration of his paper on "Photo-Electricity," read at the previous meeting. In one of these, a seleno-aluminium battery, illuminated by the light of a taper, deflected an electrometer needle, thereby actuating a relay and ringing a bell. He afterwards exhibited one of his "impulsion cells" in action, and showed the change from the insensitive to the sensitive state produced by a Hertz oscillator at a distance.

In the discussion, Mr. Tunzelmann said Kalischer and Von Uljanin had worked at the same subject, the former being the first to make experiments on a photo-electro

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With a Two-Page Engraving of a PASSENGER CARRIAGE FOR THE HOELLENTHAL RAILWAY.

NOTICES OF MEETINGS.

THE INSTITUTION OF CIVIL ENGINEERS.—Ordinary meeting, Tuesday, March 3rd, at 8 p.m. Paper to be read with a view to discussion: "On the Subterranean Water in the Chalk Formation of the Upper Thames, and its Relation to the Supply of London," by Mr. John Thornhill Harrison, M. Inst. C.E. Also ballot for members and (at 9 p.m.) reception by the President and Council. —Students' meeting, Friday, February 27th, at 7.30 p.m. "Disintegrators," by Mr. Bertram Chatterton, Stud. Inst. C.E. Professor Unwin, F.R.S., M. Inst. C.E., in the chair.—Students' visit, Monday, March 2nd, at 2 p.m., to the Locomotive and Carriage Works of the Great Eastern Railway, at Stratford.

THE SURVEYORS' INSTITUTION.—Monday, March 2nd, adjourned discussion on "Recent Legislation as to Buildings and Streets in London," by Mr. A. A. Hudson (Associate), at the last meeting will be resumed. The chair to be taken at 8 p.m.

SOCIETY OF ENGINEERS.—Monday, March 2nd, at the Town Hall, Westminster. A paper will be read on "The Balancing of High-Speed Steam Engines," by Mr. Arthur Rigg. The chair will be taken at 7.30 p.m. precisely.

ENGINEERING.

FRIDAY, FEBRUARY 27, 1891.

THE NAVY ESTIMATES.

THE Navy Estimates have been issued so close upon our going to press that we have not had time to do more than glance through them, and we will therefore simply give a few of the leading features at present, deferring a more detailed notice until next week. The statement of the First Lord, which has become so welcome an accompaniment of the estimates since Lord George Hamilton took the reins—or rather the yoke lines—at Whitehall, was given to the public a few hours earlier than the formal estimates, but we prefer to deal with both documents at the same time. For the present financial year (1890-91), the total estimates were 13,786,600*l.*; for the next year, which begins in April, they will be somewhat more, viz., 14,215,100*l.*; an increase of 428,000*l.* The following are some of the chief items of gross estimates, including "appropriations in aid," wages of officers and men, 3,564,778*l.*; victualling and clothing, 1,475,052*l.*; shipbuilding vote: Section I., *personnel*, 1,787,470*l.*; Section II., *matériel*, 2,077,600*l.*; Section III., contract work, 1,300,400*l.*; naval armaments, 1,595,310*l.*; works and buildings, 424,900*l.*; Admiralty Office, 229,620*l.* The above are included in the effective services. The non-effective services, half-pay, pensions, &c., amount to 2,060,167*l.* The total number of officers, seamen and marines, including coastguards, provided for, is 71,000.

The increase of expenditure this coming year is, the First Lord explains, associated with an increase of duties on the part of the naval branch of Her Majesty's service. The naval ordnance stores having been transferred from the War Office to the Admiralty, this entails a special expenditure of 78,000*l.*, to meet which 70,500*l.*, hitherto borne on Army estimates, has been transferred to Navy votes. On the other hand, an increased appropriation is anticipated from the Indian Government in aid of naval funds for work done in Indian waters. The full subsidy payable under the Imperial Defence Act by the Australian colonies will become due this financial year. Against this has to be put the cost of keeping in commission and reserve the seven ships constituting this special squadron, and the payment of an annuity for the redemption of the original cost of the construction and equipment of these vessels. The last instalment of this annuity will be paid on April 1, 1900. Including these various contributions and items, the net increase to Navy votes is reduced to 358,500*l.*

At the close of the present financial year (1890-91) the only ship of the old programme (the cost of which is met by the annual estimates and not by the Naval Defence Act) that remains to be finished, so far as contract work is concerned, is the Blenheim, which, however, will be handed over next August. Of the seventeen second-class cruisers building by contract, eight have been launched, and one, the Latona, has been delivered at Portsmouth, where she is now completing for sea. A number of the remaining vessels of this class are rapidly advancing, and will be speedily set afloat. It is anticipated that, with two exceptions, all of them will be delivered by the ensuing autumn, and the remaining two before April, 1892. The five first-class cruisers building by contract are also making good progress, and will be launched during the year 1891-92. Three of the four first-class battle-ships building by contract are now considerably advanced. The fourth is in an earlier stage of construction. The whole of the contract programme of the Naval Defence Act has been thus placed, except six vessels of the torpedo gun type. They will shortly be put out to contract. As they are of small dimensions, their construction and completion will not occupy more than eighteen months. The completion of the five cruisers and two torpedo gun boats (the Australian flotilla), building under the Imperial Defence Act of 1888, has been delayed by the conditions of the market, both as regards labour and materials, but the vessels will all be ready for commission within the financial year 1890-91.

The First Lord in his statement gives a few details of the designs of second-class battle-ships. They are to be 360 ft. by 70 ft. and of 10,500 tons displacement. The speed, with forced draught, is to be 18 to 18½ knots, a forecast which may be taken with a grain of salt, considering that on the opposite page we are informed that vessels are taken over without the forced draught contract trials being carried out. It may be, however, that further investigations may enable the Admiralty engineers to overcome the difficulties with regard to forced draught under which they have of late been labouring.

After some further remarks upon new designs the report goes on to deal with dockyard-built ships. All the vessels commenced in the Royal dockyards before the year 1889-90 will be completed next year, with the exception of the Blake, which will follow in 1891-92. The number of ships of all classes building, or to be built, in the dockyards under the Naval Defence Act of 1889, by March 31, 1894, was thirty-eight, and they comprise four first-class battle-ships, two second-class battle-ships, four first-class cruisers, twelve second-class cruisers of the Apollo and Astræ classes, four second-class cruisers of the Pandora class, and twelve torpedo gunboats. Twenty-eight of these vessels are in hand, and are being advanced with great rapidity. Of the remaining ten, five second-class cruisers of the Apollo class will be commenced during the financial year 1891-92, and five torpedo gunboats will be laid down in the financial year 1892-93. The first of the four first-class battle-ships, the Royal Sovereign, building at Portsmouth, was launched yesterday; the second, the Renown, building at Pembroke, will be launched in May next; and the third, the Hood, at Chatham, will be ready for launching shortly. The Royal Sovereign was laid down in the month of September, 1889, and the work upon her and the other vessels of her class has been performed with unprecedented quickness and economy. The two second-class battle-ships have just been commenced. The first of the four first-class cruisers, the Edgar, was launched at Devonport in November last; the second, the Royal Arthur, was launched at Portsmouth yesterday; and the third, the Hawke, is nearly ready for launching at Chatham. One of the second-class cruisers was launched last August, and the second was launched on February 10. Three of the second-class cruisers of the Pandora class are already afloat. Two of the torpedo gunboats, the Gossamer and Gleaner, have been launched, and are nearly complete.

The report also refers to the questions of machinery and steam trials, and the working of the Naval Defence Act. The naval ordnance question is also dealt with. Matters relating to personal and general administration are also noticed at some length; but these matters we must leave for a future notice.

TRIAL OF A 66-TON CANET GUN.

A WRITER in the *Times* recently said: "We are informed that the Sans Pareil 110-gun has been very recently tried at Shoeburyness. The gun, it is stated, was fired at a target, with the result that the projectile fell short and was also deflected considerably to the right. The official excuse is that the sighting of the gun had not been properly adjusted. At all events the gun was not fired again, as originally intended, when Lord George Hamilton and a party of distinguished officers were present the next day at experiments with the Zalinski gun. Is it possible that the sighting requires readjustment after every single round fired? Perhaps Lord George Hamilton may deem it desirable to explain this remarkable performance of the gun." To this we may add that while it is quite possible the sights had not been properly adjusted, it is also quite certain that the bore of the gun drooped after firing, and not only drooped, but was laterally

OFFICIAL FIRING TRIALS OF A 12.6-IN. CANET GUN CARRIED OUT IN JANUARY AND FEBRUARY, 1891.
GUN NO. 1.

Weight of Shell.		Description of Powder.	Weight of Charge.		Muzzle Velocity.		Pressure.		Penetration in Wrought Iron.		REMARKS.
kilos.	lb.		kilos.	lb.	metres	feet	kls. per sq. cm.	tons per sq. ft.	cm.	in.	
346	762.8	P.B.S. 3rd sample (1890.)	119.90	264.3	506	1660	670	4.25	..	..	1st trial, January 22.
346	762.8	Ditto	139.45	307.4	547	1795	888	5.64	..	..	Ditto
348	767.2	Ditto	160.05	352.8	599	1965	1379	8.75	..	..	Ditto
345.5	761.7	Ditto	159.00	350.5	596	1955	1410	8.95	..	..	Ditto
448	987.7	Ditto	159.45	351.5	546	1791	1500	9.52	77.4	30.47	2nd trial, January 23.
448	987.7	Ditto	179.70	396.1	575	1886	1559	9.90	83.8	33.00	Ditto
448	987.7	Ditto	199.30	439.4	613	2011	2089	13.26	92.5	36.41	Ditto
452	996.5	Ditto	209.70	462.3	635	2083	2205	14.00	97.7	33.46	Ditto
455	1003.1	Ditto	224.20	494.2	655	2149	2292	14.55	102.4	40.32	3rd trial, January 24.
447	985.5	Ditto	240.00	529.1	679	2228	2575	16.35	108.3	42.64	Ditto
350	771.6	B N.	100	220.5	518.7	1702	758	4.81	..	..	4th trial, January 27.
451.5	995.3	Ditto	110	242.5	552.8	1813	1221	7.75	78.9	31.06	Ditto
447	985.5	Ditto	120	264.5	592.6	1944	1408	8.94	87.9	34.61	Ditto
452	996.5	Ditto	130	286.6	658.3	2160	1962	12.45	103.2	40.63	Ditto
451.5	995.3	Ditto	135	297.6	701.7	2302	2392	15.19	113.9	44.85	5th trial, January 28.
448.5	988.7	Ditto	138	304.2	696.7	2286	2140	13.59	112.7	44.37	Ditto
469	1034.0	P.B.S.	245	540.1	689.6	2262	2439	15.49	114.7	45.16	Ditto
448.5	988.7	Ditto	255	562.2	703.6	2306	2669	16.95	114.5	45.06	Ditto
449	989.9	B.N. 6th sample (1890).	108	238.1	632	2073	1655	10.51	96.9	38.15	6th trial, January 30.
450.5	993.1	P.B.S.	240.30	529.7	676	2218	2389	15.17	107.5	42.33	7th trial, February 2.

NOTE.—These trials were not carried out by the constructors of the gun, but by the representatives of the Japanese Government and by French officials.

deflected. Considering the unsatisfactory condition of our heavy ordnance, and the almost invariably alarming results that follow whenever those in authority muster sufficient courage to fire one of our 110-ton guns (we believe we are correct in stating that not one of these guns has ever yet been fired with its full powder charge and maximum weight of projectile), it is interesting to notice what is being done in France at the present time with heavy guns, not so large certainly as those which are occasioning so much embarrassment here, both to their designers and to those entrusted with the responsibility of firing them, but of a calibre probably the largest that will ever be used successfully in war, and which certainly leave little to be desired so far as perfection of material and construction are concerned.

It may be remembered that some time, since the Japanese Government ordered the construction of several ships of war, especially intended for coast defence. Of these, some have been built in Europe and the remainder in Japan. The efficient armament of these ships was a subject that naturally demanded the best attention of the advisers to the Japanese Government, and it was finally determined that the best, though not the heaviest, ordnance that could be obtained, should be purchased. When this important order was placed on the market very keen competition ensued between the responsible manufacturers of ordnance in Europe; the contract was finally obtained by the Forges et Chantiers de la Mediterranée, and was forthwith set in hand at their Havre gun factory. The calibre decided on was 32 centimetres (12.6 in.), the weight was 66 tons, and the total length of the gun is 40 calibres. We published some time since a section of these guns (see the two-page engraving in ENGINEERING, vol. xlix, page 586); more recently we published an engraving of the finished gun mounted on its carriage, which was also made by the Forges et Chantiers, and is, for each gun, on the Canet system. The testing of one of these guns took place a few weeks since in the company's Polygon at Hoc, and the trial naturally attracted considerable interest. The above Table gives full particulars of this trial, and shows that the results obtained surpass what was anticipated, probably even by the manufacturers themselves. The weight of the projectiles fired varied from 346 kilos. to 469 kilos. (762.8 lb. to 1034 lb.), and the weight of the powder charge from 220.5 lb. to 562.2 lb. With the heaviest charge an initial velocity of 703 metres (2308 ft.) was imparted to the projectile, representing a striking energy at the muzzle of 11,300 metric tons. This represents a penetrating power of the projectile equal to overcoming the resistance offered by a wrought-iron armour-plate 45.16 in. thick, and established the reputation of these guns as the most powerful which have yet been manufactured in France, and probably in the world. The 42-centimetre (16.54-in.) gun in the French Navy has only a penetrating energy at the muzzle equal to an iron armour-plate 37.79 in. in thickness. At a range of 2000 yards the Canet gun, the trial of which we are describing, would pierce an armour-plate 37.79 in. in thickness, while the 42-centimetre French naval gun would penetrate to a depth of 30.71 in. only, at a similar range, assuming that it would be able to withstand successfully the heavy strains set up by the explosion of the large powder charge required. The new 66-ton Canet gun was proved on the same occasion to have a maximum range of 21 kilometres (over 13 miles), that is to say, that if it were discharged at Versailles the projectile would drop in the heart of Paris. As will be seen from the Table, the official test of the gun tried recently, and which is the first of the whole number that will ultimately constitute the armament of the Japanese coastguards, consisted of twenty rounds fired with varying charges and under different conditions. One interesting feature connected with these tests, was the great facility with which the breech mechanism was operated, all the numerous manœuvres required being easily performed by one man. The carriage upon which the gun was mounted was tested at the same time, and after the whole series of twenty rounds had been fired, a minute examination proved that it had in no way suffered from the heavy strains thrown upon it.

The Forges et Chantiers de la Mediterranée are certainly to be congratulated upon the brilliant success they have achieved with this gun, and the Japanese Government may lay claim to the proud distinction of possessing what is probably the most powerful ordnance that has yet been constructed—that is to say in a practical sense of the word. The endurance of these guns is likely to be very considerable, probably greater even than that of the budget of the Japanese Admiralty, considering that the cost of firing each round will be at least 400*l*. As this was the expense during the recent trials at Hoc it will be seen that efficiently testing a 66-ton gun is a costly matter, no less than 8000*l*. having been fired away on that occasion.

THE ELECTRIC TRANSMISSION OF POWER.

IT is an essential condition with most prime movers that they should run constantly at or about the same speed, whatever may be the variation in the load. As the work increases on a steam engine the governor admits more steam, and as the work diminishes the supply of steam is reduced. In an electric motor, however, the supply of current cannot be regulated by a device like a throttle valve, and uniformity of rotation has to be attained by other means. An investigation into conditions of electric motors favouring automatic regulation, formed the chief part of Mr. G. Kapp's second Cantor lecture on "The Electric Transmission of Power," delivered last Monday evening before the Society of Arts.

Electric motors may run under either of two sets of conditions. When they receive their current from the mains of a supply company, which is the usual condition of small machines in towns, there is a constant pressure at the terminals. When a special generator is erected to supply current to a distant motor then there is constant or variable pressure with a variable power absorbed by the generator. If a series motor be employed with constant pressure at the terminals, then with light loads the speed will run up until the counter electromotive force is nearly equal to that at the terminals, and the current is reduced to a small amount. The strength of the field will fall off as the speed is increased, since the same current circulates in it as in the armature. An increase of load will demand an increase of current both in the armature and field, but since the counter electromotive force in the armature depends both on the speed and the strength of the field, it follows that a large current means decrease of speed, or in other words, that the motor runs slower when fully loaded than when lightly loaded.

A shunt motor does not suffer from the variation of current through its field coils. As long as the difference of potential remains constant, the same current will always flow whatever may be the load on the armature. By varying the electromotive force by the insertion of resistances the speed can be altered accordingly. To demonstrate this Mr. Kapp first ran a shunt-wound motor with a difference of potential at the terminals of 70 volts; the speed was 358 revolutions per minute. He then raised the potential to 92.5 volts by taking out resistances, when the speed became 455 revolutions. The speeds were shown to be proportional to the electromotive forces, within the limits of error of a platform experiment. This method of regulation is, however, wasteful, since the resistance consumes energy without giving any useful return. Further, if the loads be very heavy, the armature exercises a demagnetising effect on the field magnets, and the field no longer remains constant. Another method of varying the speed of a shunt motor is by varying the strength of the field. If the field be strong a moderate speed gives a high counter electromotive force, while, on the contrary, with a weak field the armature must run fast before the electromotive force nearly balances that in the mains. Mr. Kapp had devised a very striking method of illustrating this to his audience. A motor, supplied with current from a source outside the hall, drove a dynamo, in the circuit of which was an arc lamp. It was easy to see from the light given off how the speed of the dynamo was altered by modification in the field of the motor. At starting, the lamp just maintained its arc and nothing more, but when resistance was added to the magnet circuit of the motor, a long arc was drawn and abundant light given off, thus showing that both increased speed and power were obtained. The conditions of the experiment corresponded to a case where the speed is not required to be uniform but to be capable of easy regulation. For a constant speed under varying loads a shunt motor regulates automatically. This was shown by experiments published by Mr. Mordey in the *Philosophical Magazine* for January, 1890. With a supply at 140 volts pressure, and a load varying between 1.8 and 16.3 horse-power, the difference of speed was only 3 per cent. The condition requisite for good regulation is that the loss of voltage in the armature, due to the resistance, must balance the armature reaction on the fields. That is, that the demagnetising effect of the armature on the field, which would give rise to an increased speed of rotation, must be met by a loss of electromotive force in the armature itself, the field strength and the electromotive force increasing and decreasing together. If the motor be compound wound, the effect of the series coils is to weaken the field, or to assist the armature reaction. Experiment showed that the motor in the lecture room ran about 8 per cent. faster loaded than when light; the armature resistance and reaction did not exactly balance each other.

When the current is not taken from general supply mains, but from a special generator, it is possible to use series, compound or shunt motors. If both generator and motor be series wound it is possible to design them to give constant speed at all loads. When the current driving a motor is derived from a series-wound dynamo, neither the current nor the electromotive force is constant.

course, have acquired by long experience so much information with regard to agreements, contracts, and the like matters of every-day occurrence, that they are quite as competent to deal with these as most lawyers. But much litigation would at the same time be avoided if the necessary incidents of contracts with corporations, joint stock companies, local companies, and the like, were more generally appreciated. It should, of course, be universally known that all corporations can only contract under their common seal with some few exceptions, but the considerable amount of litigation which arises in this context illustrates the difficulty of the point. The case of the Tunbridge Wells Improvements Commissioners v. the Southborough Local Board (which was decided in 1888), shows the inconvenience, not to say hardship, resulting. Here the plaintiff agreed to transfer certain land to the defendant on condition that the defendant adopted a certain road and dedicated it to the public. The agreement was not under seal, and it was held by Mr. Justice Kay that the contract did not justify the requirements of the Public Health Act, s. 174, ss. 1, and was therefore invalid. This shows that although the Public Health Act dispensed with the necessity of the corporate seal being affixed to give validity to contracts under 50*l.*, over that amount they must still be by deed, and the point illustrates many which daily need elucidation. Messrs. Macassey and Strahan recall the old suggestion, which seems to us to be well worthy of attention, that a limitation should be attached to the liability of an engineer under a contract, although he can only earn his 5 per cent. on the contract sum, he is liable to an action which may cast him in heavy damages. We do not know whether it would be feasible to reduce his liability to the amount of his fees, but it certainly seems that there should be some limit since the engineer is very often made to blame for the contractor's shortcomings. In other respects engineers and others are placed in an unfair position by operation of law. We may take for instance the case of their liability under the Public Health Acts. It is highly important that they should bear in mind that no officers or servants appointed or employed under the Act shall in any wise be concerned or interested in any contract made with the local authority, and that all such contracts are illegal and void. Many cases have of course arisen under these Acts, and many of them have disclosed facts of considerable hardship. As illustrating the minor matters which deserve the attention of engineers, the case of Cann v. Willson is useful and instructive. It has certainly been believed that the engineer is not any more liable than the employer as warranting the correctness or feasibility of any plan, specification, or bills of quantities. In fact, briefly put, his liability has been regarded as being limited to wilful inaccuracies or fraudulent misrepresentation, and not to mere mistakes, but this case (which was heard in 1888) seems to show that loss arising from the inaccuracy of the valuation can be sued for. It has yet to be shown whether this ruling would extend to blunders in a plan, specification, or bill of quantities, but if so it certainly seems to increase the liabilities of professional men. But we have said enough to show the scope of the volume.

BOOKS RECEIVED.

The Cruise of the Royal Mail Steamer Dunottar Castle round Scotland on her Trial Trip. Edinburgh: T. and A. Constable.

An Explanation of the Phonophore, and more especially of the Simplex Phonophore Telegraph. By C. LANGDON-DAVIES. London: Kegan Paul, French, Trübner, and Co., Limited.

General Booth and his Critics. By H. GREENWOOD, M.A., LL.D. London: Howe and Co.

Sewage Treatment; or the Purification of Water-Carried Sewage. By H. LEONARD HINNELL, Assoc. Memb. Inst. C.E. Bolton: Tillotson and Son. [Price 1s.]

Lessons in Applied Mechanics. By JAMES H. COTTERILL, F.R.S., and JOHN HENRY SLADE, R.N. London: Macmillan and Co. [Price 5s. 6d.]

Annual Report of Regents of the Smithsonian Institution, showing the Operations, Expenditures, and Condition of the Institution for the Year ending June 30, 1886. Part II. Washington: Government Printing Office.

The Law of Joint Stock Companies. By JAMES WALTER SMITH, LL.D. London: Effingham Wilson and Co. [Price 1s. 6d.]

Transactions of the Sanitary Institute. Vol. X. Congress at Worcester. London: Offices of Sanitary Institute, and Edward Stanford.

Structural Mechanics; a Handbook for Engineers, Architects, and Students. By R. M. PARKINSON, Assoc. M.I.C.E. London: George Bell and Sons.

Text-Book on the Steam Engine, with a Supplement on Gas Engines, and Part II. on Heat Engines. By T. M. GOODEVE, M.A. Eleventh Edition, enlarged. London: Crosby Lockwood and Son.

Laxton's Builders' Price Book for 1891, containing above 72,000 Prices. Originally compiled by WILLIAM LAXTON. Seventy-fourth Edition. London: Kelly and Co.

Applied Mechanics. By GAETANO LANZA, S.B., C. and M.E. Forth Edition, revised and enlarged. New York: John Wiley and Sons.

Spon's Engineers' Diary and Reference Book for Engineers, Machinists, Contractors, and Users of Steam, for 1891. London and New York: E. and F. N. Spon.

The Washington Bridge over the Harlem River at 181st Street, New York City. A Description of its Construction. By WILLIAM R. HUTTON, Chief Engineer. Illustrated with Twenty-six Alberttypes, and Thirty-seven double and single-page Lithographs. New York: Leo von Rosenberg. [Price 8 dols.]

Irrigation Developments. History, Customs, Laws, and Administrative Systems relating to Irrigation, Water Courses and Waters in France, Italy, and Spain. The Introductory Part of the Report of the State Engineer of California on Irrigation and the Irrigation Question. By WM. HAM. HALL, C.E. Sacramento: State Office.

Irrigation in California (Southern). The Field, Water Supply, and Works, Organisation and Operation in San Diego, San Bernardino, and Los Angelos Counties. The Second Part of the Report of the State Engineer of California on Irrigation and the Irrigation Question. By WM. HAM. HALL, C.E. Sacramento: State Office.

On Consumption of the Lungs, or Decline, and its Successful Treatment. By GEORGE THOMAS CONGREVE. New and enlarged Edition, with Appendix. London: Elliot Stock. [Price 1s.]

The Incorporated Gas Institute Transactions, 1890. Edited by W. H. HARVEY, Secretary. London: Office of the Institute. [Price 10s. 6d.]

The Design of Structures: A Practical Treatise on the Building of Bridges, Roofs, &c. By S. ANGLIN, C.E. With numerous Diagrams, Examples, and Tables. London: Charles Griffin and Co.

An Elementary Course on Mechanical Drawing. Part I. —*Loci (including Point Paths in Mechanism and Exercises on Valve Gear).* By ALEXANDER MACLAY, B.Sc., M.I. Mech. E. Manchester: The Technical Publishing Company, Limited.

A Dictionary of Metric and other Useful Measures. By LATIMER CLARK, F.R.S. London and New York: E. and F. N. Spon.

Die Graphische Statik. Bearbeitet von R. LAUENSTEIN. Mit 155, Holzschnitten. Stuttgard: F. G. Cotta.

An Elementary Treatise on Mechanics for the Use of Schools, and Students in Universities. By Rev. ISAAC WARREN, M.A. Part II., *Dynamics.* London and New York: Longmans, Green, and Co. [Price 3s. 6d.]

Hydraulic Machinery Employed in the Concentration and Transmission of Power. By G. CROYDON MARKS, A.M.I.C.E., M.I.M.E. Manchester: The Technical Publishing Company, Limited.

Ventilation; a Text-Book to the Practice of the Art of Ventilating Buildings. With a Supplementary Chapter on Air Testing. By WILLIAM PATON BUCHAN. With 170 Engravings. London: Crosby Lockwood and Son.

Minutes of Proceedings of the Engineering Association of New South Wales. Vol. IV. Edited by HENRY V. AHRBECKER, Hon. Sec. Sydney: Published by the Association.

"*The Electrician" Electrical Trades Directory and Handbook* for 1891. London: *The Electrician* Printing and Publishing Company, Limited.

Die Elektrischen Verbrauchmesser. Von ETIENNE DE FODOR. Mit 77 Abbildungen. Vienna, Pesth, and Leipzig: A. Hartleben.

The Labour Movement in America. By RICHARD T. ELY, Ph.D. London: William Heineman.

The "Shipping World" Year-Book; a Desk Manual in Trade, Commerce, and Navigation. Edited by EVAN ROWLAND JONES. 1891. London: *Shipping World* Office.

A Treatise on the Law and Practice Relating to Letters Patent for Inventions. With an Appendix of Statutes, International Convention, Rules, Forms, and Precedents, Orders, &c. By ROBERT FROST, B.Sc. (Lond.). London: Stevens and Haynes.

The Elements of Machine Design. Part II. *Chiefly on Engine Details.* By W. CAWTHORNE UNWIN, F.R.S. New (eleventh) Edition, revised and enlarged. London and New York: Longmans, Green, and Co.

The Electro-Plater's Handbook. A Practical Manual for Amateurs and Young Students in Electro-Metallurgy. By G. E. BONNEY. With Sixty-one Illustrations. London: Whittaker and Co.

MODERN FRENCH ARTILLERY.
No. LVIII.

HOTCHKISS QUICK-FIRING GUNS—*continued.*

WE now come to a consideration of the various kinds of ammunition used in the various calibres of rapid-firing guns. For all sizes the powder charge and projectile are combined in one, by means of a solid drawn cartridge case, the made-up patterns, which are of the oldest date, being still largely used. Figs. 606 and 608, page 272, are a plan and section of a made-up case. The body consists of a solid drawn brass tube reduced in diameter where it will receive the projectile, and flanged in at the base; an internal angled ring of brass and a similar external one, are placed at the base, and a wrought-iron disc with rounded edges, and of a diameter slightly larger than that of the tube, is rivetted to the base as shown; the projecting rim keeps the cartridge in place in the gun, and affords a grip for the extractor. The whole of these various parts are so closed that they are entirely gas-tight; in a hole in the middle of the iron base is placed the primer containing a percussion cap. Figs. 607 and 609 show a solid drawn case, which has the advantage for small calibres of being cheaper, stronger, and more accurate than made-up ones; but the former quality disappears with the larger sizes, until with the 10-centimetre gun, the cost is about twice as great. For obvious reasons also the weight is greater, and probably the claim that such heavier cartridge cases can be used many times over, without resizing, is factitious, on account of the waste inevitable during action. Whichever type of cartridge case may be employed, the projectile and powder charge are similar. Of the several types of the former, the steel shell is the most efficient for attack against plating; it is sharp-pointed and of a high quality of very hard metal; the base is screwed into the body, to prevent premature fracture before leaving the gun, and the fuze is screwed into the base; Fig. 627 is a section of such a shell. The cast-iron or common shell is made in one piece with an opening in the head by which it is charged and to which the fuze is screwed. In both classes the shell near the base is slightly swelled and brass bands are added to take the rifling. The case of the shrapnel (Figs. 622 and 629) is made up of three parts—the head, body, and base. The head is of brass coned and with an opening at the top into which the fuze is screwed; the body is a thin steel tube, weakened symmetrically by cutting, so as to predetermine fracture, the upper part of the body is set round the head, and the base—a steel plug—is driven into the other end. The contents, besides the bursting charge, which is carried in the head, consist of tiers of hard lead bullets, separated, for all calibres above 3-pounders, by cast-iron plates of such a form that each breaks up into six fragments, adding considerably to the destructive effect of the explosion; for the 6-pounder gun the number of fragments thus obtained at each discharge is 100; the shell is fired by an Armstrong combination time and percussion fuze, the time portion being regulated for eight seconds, equivalent to a range of 3100 yards. The case shot are formed of a thin short brass shell with a soft metal base to take the rifling and a conical head. The case is filled with hardened lead bullets to the number of fifty in the 3-pounder, and eighty in the 6-pounder; the intervening spaces are filled with sawdust (see Fig. 628).

The various fuzes employed are illustrated by Figs. 610 to 620. Figs. 615 to 617 show the Hotchkiss base percussion fuze used for steel and cast-iron shell; it consists of a gun-metal body threaded near the base for screwing into the bottom of the projectile. In the head is screwed a cap with a pierced plug and containing a percussion cap. The cylindrical portion of the fuze is occupied with a loose fitting plunger filled with lead, the top surface being cupped as shown; this plunger is cast on a central pin with pointed head, and the position before firing of the various parts is that shown in Fig. 616. As the shell is projected from the gun, the leaden piston is driven down the pin on which it is mounted, and occupies the position shown in Fig. 617; on the shell striking an object, the piston flies forward carrying the pin, which is formed with roughened sides to afford a hold, and the point of this latter strikes the percussion and fires the bursting charge. The Hotchkiss point percussion fuze is shown in Figs. 612 to 614. This consists of a cylindrical brass body screwed into the head of the shot covered by a gun-metal conical cap from the middle of which a point projects inwards; the bottom of the body has a tapering hole into which a plug is driven, and the function of which is to hold in place the two ends of a brass wire bent round and secured to the plunger, which is a brass casing filled with lead, and containing a small charge of fulminate and priming powder. When the shot is set into rapid motion the plunger is forced to the base of the chamber, driving out the lead plug that falls into the shell; when the point of the latter strikes, the plunger is forced violently against the head, and the fulminate strikes the point in the cap, firing the fuze and exploding the charge.

The Desmarest percussion fuze used by the Hotchkiss Company is a somewhat elementary one. It consists of a brass casing, screwed into the shell,

AMMUNITION FOR HOTCHKISS QUICK-FIRING GUNS.

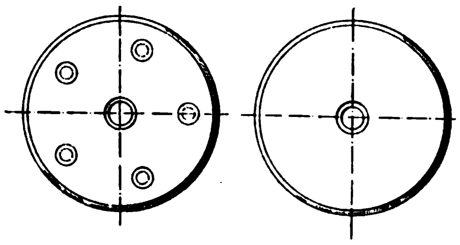

FIG. 606. FIG. 607.

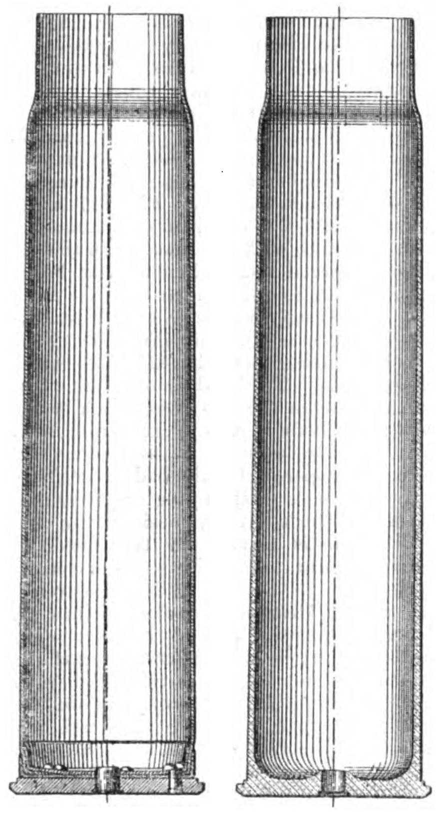

FIG. 608. FIG. 609.

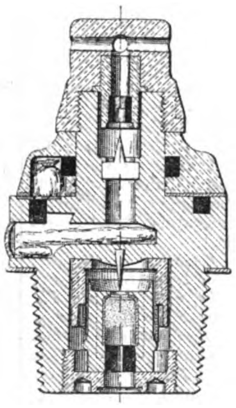

FIG. 610.

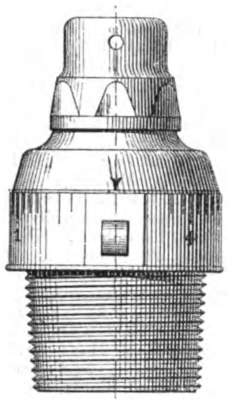

FIG. 611.

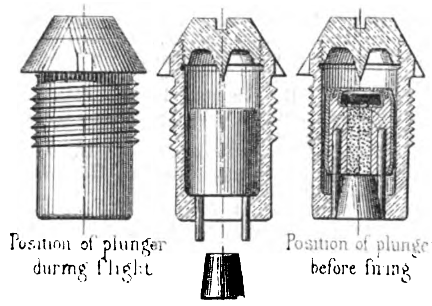

FIG. 612. FIG. 613. FIG. 614.

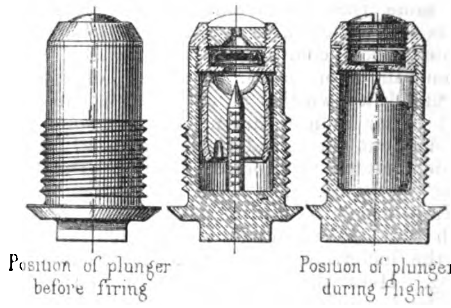

FIG. 615. FIG. 616. FIG. 617.

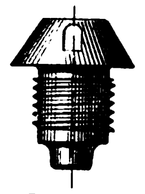

FIG. 618.

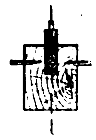

FIG. 619.

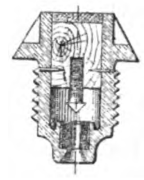

FIG. 620.

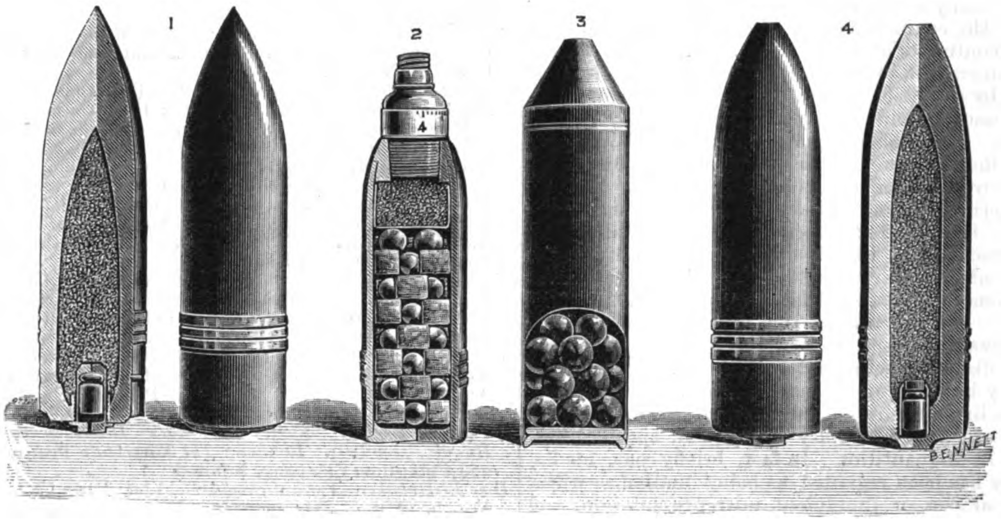

FIG. 621. FIG. 622. FIG. 623. FIG. 624.

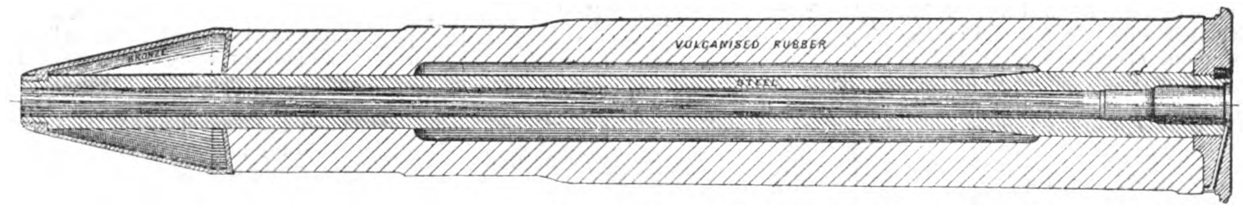

FIG. 625.

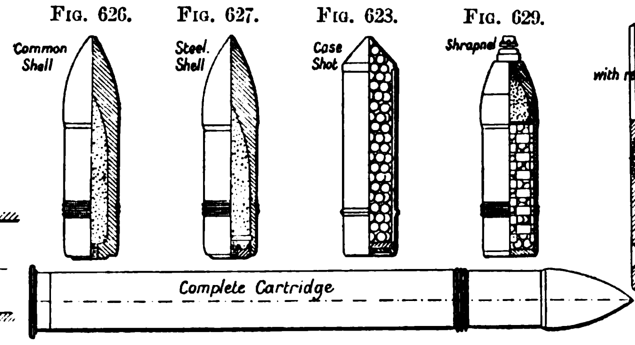

FIG. 626. FIG. 627. FIG. 623. FIG. 629.

FIG. 630.

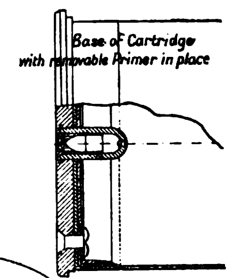

FIG. 631.

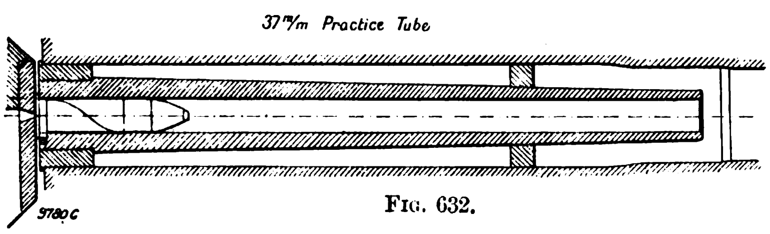

FIG. 632.

carrying a percussion fuze and firing charge in the base; in the head of the fuze is a wooden plug hung to the side of the casing by two light wires, the top of the fuze above the wood is filled in with putty. On the shell striking, the wood plug is driven inwards, and the point projecting from the inner side is forced against the percussion cap (see Figs. 618 to 620). The Armstrong combination time and percussion fuze (Figs. 610 and 611) is necessarily elaborate in design. The body is made of an alloy of lead, tin, and antimony, the lower part being screwed into the shell; it is in the recess in this part of the fuze that the percussion device is placed. The central portion of the fuze is of an enlarged diameter, and contains a recess for holding the composition for

10-CENTIMETRE (3.39-IN.) HOTCHKISS QUICK-FIRING GUN AND DECK MOUNT.

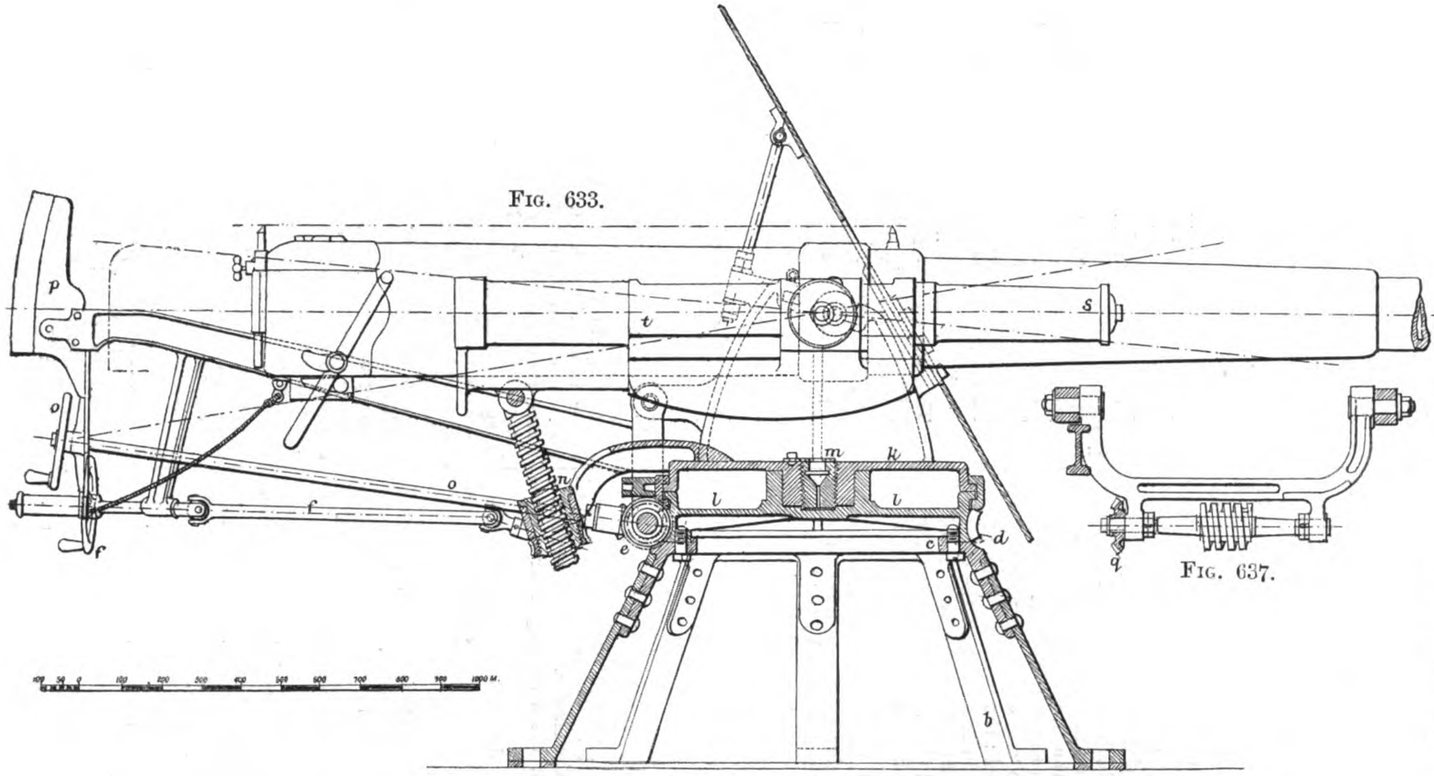

FIG. 633.

FIG. 637.

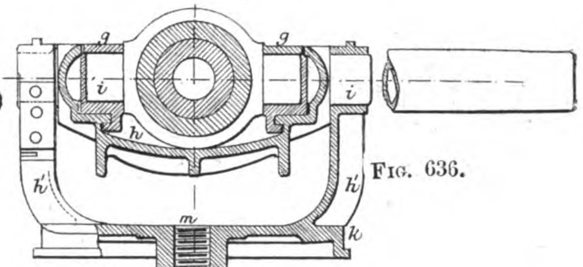

FIG. 636.

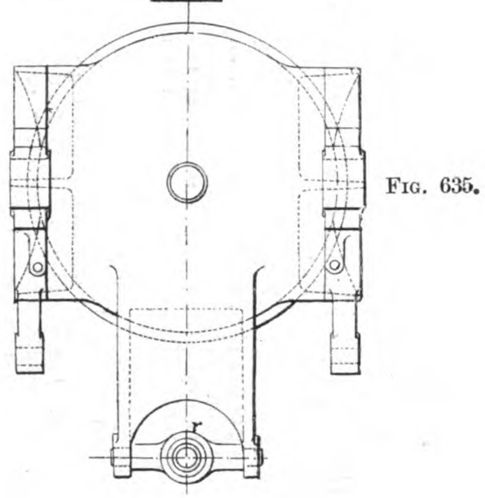

FIG. 635.

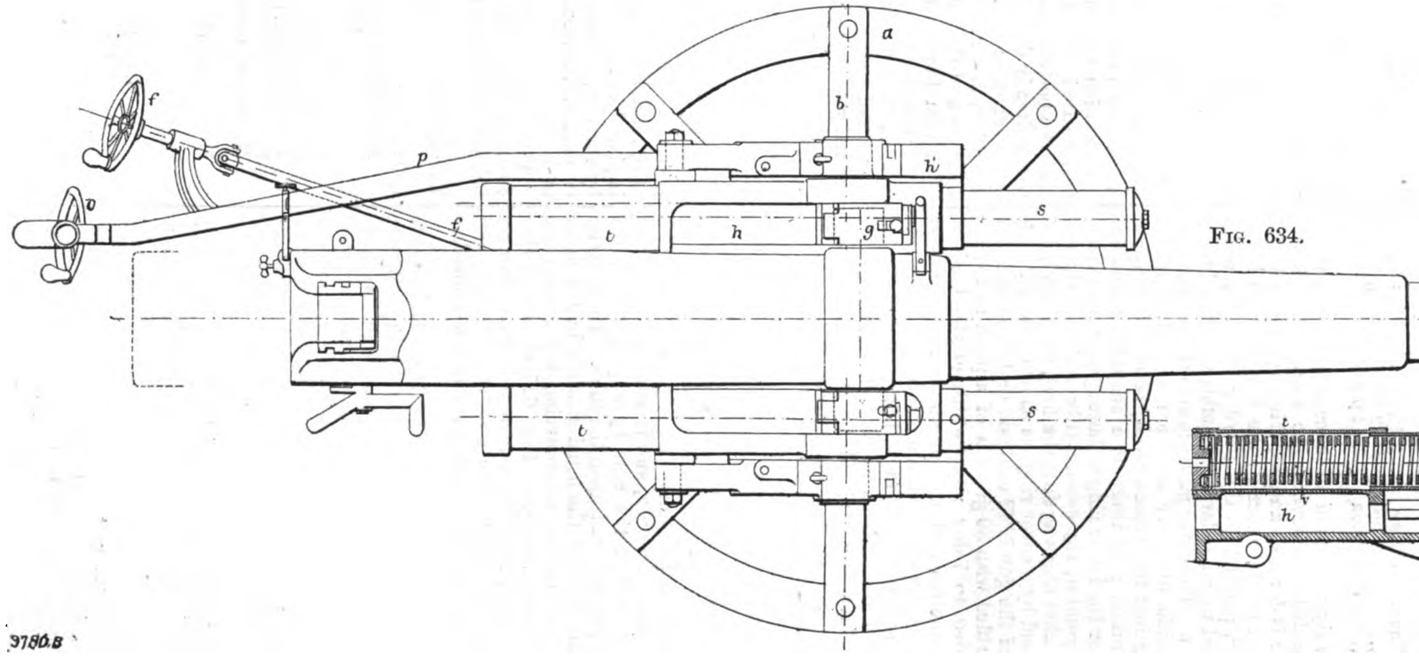

FIG. 634.

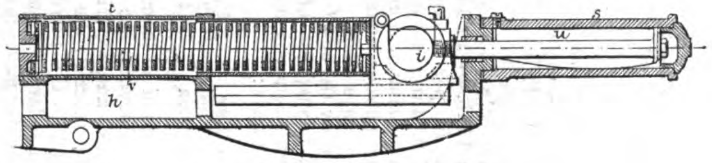

FIG. 638.

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the time fuze. Around the periphery of this portion there is a graduation into inches and tenths. The upper part of the fuze is of smaller diameter, and is chambered to contain the time circuit and igniting arrangement; the whole device is closed by a screw cap. The percussion device in the lowest part of the fuze is of the ordinary type, comprising a plunger charged with powder and a fulminating cap, and a needle fixed over it, against which the plunger is driven on impact. Over the upper part of the fuze a loose disc is placed containing a ring of mealed powder, communicating with the upper percussion device, and with any desired part of the time circuit. The disc can be held fast by screwing down a cap on it; this cap holds the plunger for the upper percussion chamber, the plunger being held over a steel needle by a light copper cup that rests by projection on the top of the fuze. When the gun is fired the top plunger is driven on to the steel pin and exploded, firing the ring of mealed powder, and that part of the time circuit to which the fuze has been set. When the length has burned out it fires the lower priming charge, and by that means the shell.

The Hotchkiss 10-cent. (3.94-in.) 33-pounder rapid-firing gun, is the heaviest of this nature made by the company. In its general features it resembles the lighter guns of the same series, but it possesses many special features, especially in its mountings, which were necessary to fulfil the severe conditions for which it was designed. These conditions were that it should throw a 33-lb. shot, with a powder charge of from 11 lb. to 13.3 lb., with an initial velocity of 1968 ft. per second, a penetration at close range of 9.84 in., a rapidity of six aimed shots, or twelve maximum rounds per minute, and a strain in the powder chamber not exceeding 35,500 lb. per square inch. Figs. 573 to 577, page 216 *ante*, show the construction of this gun, which is made throughout of Creusôt steel, oil tempered and subsequently annealed, and resisting the following tests:

Minimum resistance	...	41.90 tons per sq. in.
„ elastic limit	...	22.86 „ „
„ elongation	...	14 per cent.

The body consists of an inner steel tube, parallel for some distance beyond the trunnions, where a shoulder is formed, and tapering from the end of the jacket to the muzzle; the bore is 3.94 in. in diameter, parallel to the powder chamber, which is tapered to an enlarged diameter at the breech of 4.42 in. The outer jacket is made in two lengths, the outside diameter at the rear end, where it abuts against the breech-block, being 13.39 in.; at the trunnion ring there is a shoulder round the jacket for the latter ring to butt against, and somewhat beyond it, the second tube forming the end of the jacket abuts against the first, the joint being made good by a cover ring, as shown; the extreme length of the gun is 42 calibres, or 155.58 in. The bore is rifled with 30 grooves of a pitch increasing from 0 deg. to 7 deg.; the width of the lands is 2.5 millimetres and the depth is .6 millimetre. The breech arrangement differs from that of the smaller calibres only in a few particulars; on account of the greater weight of the wedge the starting lever is arranged to give an increased purchase, and is turned through an angle of 160 deg., instead of through 90 deg., as in the lighter natures. There are also two extractors, one on each side of the breech-block. Fig. 632 shows the practice firing tube, common to the larger calibres of the Hotchkiss rapid-firing guns; this tube, which is adapted for firing the 37-millimetre (1.46-in.) ammunition, occupies the length of the powder chamber, and is supported in front by a ring and at the rear by a plug fitting the chamber and screwed upon the tube. The practice rounds are fired in the usual manner by the firing lanyard, the breech manœuvring being the same as in ordinary practice. Fig. 625 shows another form for smaller calibres, in which a dummy cartridge is placed in the gun, made hollow, and contains a tube as shown, in which a miniature cartridge is placed.

The most interesting part of this gun is the mode of mounting, which is illustrated by Figs. 633 to 638, which show the arrangement for a ship's deck. The stand is the ordinary circular steel base ring *a*, with inclined bars *b* supporting the upper ring *c*, upon which is placed a toothed wheel *d*, by which the gun can be turned horizontally through any desired angle; this gun is driven by a worm *e*, actuated by gearing and the rod and handwheel *f*, in the former of which a universal joint is introduced to allow for variations in position. The gun is supported by its trunnions in two trunnion boxes *g*, that take their bearing on a cast-steel cradle *h*, which is also provided with trunnions *i* that rest in a support, the lower part of which, *k*, is connected by clips to the revolving part of the mount; the two side standards *h'* form the bearings for the trunnions *i*. The bottom of the support is bolted to the revolving part of the mount by a central stud *m*. The trunnion boxes *g* bear upon the flat surfaces in the cradle *h* and are free to slide to and fro on them, under the action of the recoil and the brake springs which are attached to the fixed part of the carriage; at the same time the gun can be raised or lowered to any desired angle by the training screw *n*, that is worked by the handwheel *o*. The shoulder piece *p* is used only for roughly setting the gun, all the fine adjustments being done by the wheels *f* and *o*. At the same time, as the action of recoil is confined to the cradle *h*, the men serving the gun are exposed to no danger. Fig. 637 is a detached view of the bracket *f* bolted to the frame *h'* and carrying the worm *e* working the toothed wheel *d*, the handwheel and rod *f* turning the bevel wheel *q*. Fig. 635 is a plan of the lower carriage in which the cradle is held, the bracket *r* is for the nut *n* in which the elevating screw works. On each side of the gun (see plan, Fig. 634) and at right angles to the trunnions but on the same plane as their axis, are two cylinders *s t*; the former of these is a hydraulic cylinder, the rod of which is secured to the trunnion box *g*; on the opposite side is the cylinder *t* formed of two parts, one sliding within the other and containing a strong coiled spring abutting at one end against the end casting of the cylinder which is firmly secured to the cradle, and at the other end against the trunnion box *g* (see Fig. 638). On firing, the force of the recoil is resisted by the plunger in the cylinder *s* on the one hand, and by the spring V on the other. As soon as this force has been absorbed by the spring the reaction of the latter forces the gun back into its normal position, so that even in rapid firing neither the direction or elevation of the gun is affected; the length of recoil is limited to 15 in. It should be mentioned that for roughly training the gun the shoulder-piece *p* is slightly lifted and the worm *e* thrown out of gear with the wheel *d*, when the gun can be swung round freely by hand.

The ammunition employed is of the same nature as that used for the smaller calibres; it consists of common shell, steel shell, case shot, and shrapnel, all of which are set in a metal cartridge case, with a percussion cap in the base. The end of a cartridge case is shown in Fig. 631, where it will be seen that the bottom plate and stiffening ring are like those already described; the position of the primer is also shown; Fig. 630 is a view of the complete cartridge, and Figs. 626 and 627 are sections of the common and the steel shell. The case shot, formed of a thin brass envelope and iron tubing, is divided into four segments and filled with cast-iron bullets. The shrapnel, like that for smaller natures, consists of a steel tubular body, with internal longitudinal weakening grooves; it is closed by a steel base screwed in the body (Fig. 629), and the cast-iron head also screwed into the tube contains the fuze and bursting charge; the former is of the Elswick time and combination type. The body contains a number of perforated cast-iron plates which are placed to arrange the bullets symmetrically and secure a uniform scattering. It will be noticed in Fig. 631 that in the middle of the base of the cartridge is a small dome-shaped cap in which is placed a blank pistol cartridge, which is ignited by the cap, and fires the charge. The ammunition is packed in wooden cases holding four rounds each.

The following are detailed particulars of the 10-centimetre gun, its carriage, ammunition, and ballistic properties:

TABLE XCVI.—*Particulars of* 10-*Centimetre Rapid-Firing Gun and Carriage.*

1. *The Gun*:	
Diameter of bore	3.94 in.
„ body over powder chamber	13.39 „
Total length of bore (42 in. calibres)	155.58 „
Length traversed by projectile ...	11 ft. 5.80 in.
Extreme length of gun	14 „ 5.74 „
Diameter of trunnions	4.72 in.
Maximum diameter of powder chamber	4.44 „
Distance from bottom of bore to base of projectile	26.38 „
Rifling: Number of grooves	30
„ Width of lands	2.5 mill.
„ Depth of grooves	.6 „
„ Pitch	from 0 to 7 deg.
Length of line of sight	63.58 in.
Vertical distance of line of sight from axis of bore	7.59 „
Horizontal distance of line of sight from axis of bore	11.22 „
Total weight of gun	3630 lb.
Weight of wedge	132 „
Preponderance of breech	55 „
2. *Ammunition*:	
(*a*) Common shell:	
Total length	15.28 in.
Weight of body	31.71 lb.
„ bursting charge ...	18.4 oz.
„ base fuze...	2.2 „
Total weight...	33 lb.
(*b*) Steel shell:	
Total length	15.08 in.
Weight of body	31.53 lb.
„ bursting charge ...	21.25 oz.
„ base fuze...	2.2 „
Total weight...	33 lb.
(*c*) Case shot:	
Total length	14.68 in.
Number of cast-iron bullets ...	380
Weight of each bullet	1.25 oz.
Total weight...	33 lb.
(*d*) Shrapnel:	
Total length	15.08 in.
Number of bullets, hardened lead	260
„ diaphragms	13
Weight of bursting charge ...	5.3 oz.
„ combination fuze ...	10.23 „
Total weight...	33 lb.
Weight of empty cartridge case ...	9.46 „
Length „ „	29.53 in.
Weight of charge for common and steel shell	13.2 lb.
Weight of charge for shrapnel and case shot	11.0 „
Length of complete cartridge ...	41.89 in.
3. *Carriage*:	
Weight of cradle	1276 lb.
Weight of pivot with stand and training gear...	2090 „
Weight of shield	550 „
Thickness of shield	.63 in.
Area of shield	22.650 sq. ft.
Total weight of mountings	3916 lb.
Weight of gun and mountings complete	7546 „
Maximum recoil	14.96 in.
Vertical range of fire, elevation ...	+12 deg.
„ „ depression ...	-- 5 „
Horizontal range	360 „
Height of trunnion centres above deck	44.48 in.
Extreme length from muzzle to end of shoulder-piece	16 ft. 2.88 in.
4. *Ballistic Data*:	
Muzzle velocity of projectile ...	1923 ft.
Ratio of weight to that of a spherical shot of same diameter	4
Total energy of projectile	275.26 m. tons
Energy per cent. of circumference...	8.76 „
Energy per centimetre of diameter	3.50 „
„ kilogramme of gun ...	.172 „
„ „ „ powder	4.849 „
Thickness of iron plate perforated by steel shell...	9.84 in.
Rapidity of fire for aimed shots ...	6 to 8 per min.
Maximum rapidity of fire	10 „ 12 „
Number of men required to work gun at maximum rapidity... ...	4

NOTES FROM THE UNITED STATES.

PHILADELPHIA, February 25, 1891.

MANUFACTURING interests are obliged to watch the ups and downs of the money market very frequently, and just at this time the threatened stringency in money is causing a good deal of worry to promoters and managers of new enterprises. A vast amount of money is being invested in manufacturing sites, particularly in the Southern States, in view of, or rather in anticipation of, an early rapid appreciation. The available surplus of cash in the United States Treasury is to-day 33,000,000 dols. The surplus reserve in the New York banks is 15,000,000 dols., as against 3,700,000 dols. a year ago. The value of the exports of bread stuffs, provisions, cotton, and petroleum for January was 61,000,000 dols., as against 56,000,000 dols. for January last year. The net earnings of 206 railroads for the year 1890 were 328,009,458 dols., as against 313,780,569 dols. for 1889, showing an increase of 4½ per cent. The gross earnings increased last year 72,000,000 dols., and expenses 58,000,000 dols. Railroad men regard these figures as quite favourable, considering all the drawbacks to which the railroad business has been subjected. The Illinois Steel Company has increased its capital stock from 25,000,000 dols. to 50,000,000 dols. The product of the company last year was as follows; Pig iron 720,000 tons, spiegel 36,000 tons, ingots 733,000 tons, rails 509,000 tons, billets 80,000 tons, rods 54,500 tons, beams, angles, merchant iron and steel 70,000 tons. Amount of wages paid to 9648 employés 8,000,000 dols. The general iron trade has improved somewhat during the week, but there is still a backwardness to enter into large new operations. Congress will adjourn in a few days, and this in itself will afford some relief. The Silver Bill is virtually defeated. A good deal of legislature, or rather contemplated legislation, will go over to the next session, when the Democratic House will take charge. The general view entertained in business circles is that the year will be a prosperous one. Railroad building will be prosecuted chiefly in the direction of the con-