

with ore. Red dirt was ground in their skin; their boots looked as though pay dirt had been rubbed against them for weeks. The miners spent money like princes. It was a great soiree they had in the tented saloon that night spinning yarns about big strikes, rich claims yet untaken, what a rush there would be before six months, and so on. Every one seems confident that the future will bring forth rich strikes. Their present work they consider but little, and yet it is one of the greatest rushes ever made for a gold field in the Southwest. Fully 20,000 persons have been into the mountains since the opening. Six thousand claims are staked. Many mining camps are taking on life. The Wichita Mountains have begun to draw like the Klondike.—W. R. Draper, Mountain View, Oklahoma, in the New York Times.

THE VENTILATION OF TUNNELS.

The ventilation of tunnels has always been an important problem for consideration, and has attracted special attention since an accident that happened in Italy a few years ago, when a train was forced to stop for some time in the middle of a tunnel, with the result that a man lost his life through defective ventilation and the disengagement of noxious gases.

The question was then asked on all sides whether natural ventilation alone, which had been applied up to that time, was really adequate. It was remarked, in fact, that since the increase in traffic it had often

factory. In the meantime a committee of Italian railway engineers has determined the least volume of air to be discharged in order to assure a perfect ventilation.

For the same reasons of security the Paris-Lyons-Mediterranean Railway recently resolved to ventilate the Albespeyre single-track tunnel, upon the line from Nîmes to Saint-Germain-des-Fossés, and of a length of 4,800 feet, by a process analogous to that of M. Saccardo. To this effect M. E. Farcot has constructed a ventilator 19.6 feet in diameter and capable of furnishing 5,250 cubic feet of air an hour at a pressure of 1.6 inch of water. This apparatus is 8.2 feet in width and is provided with buckets four in a row. At the entrance to the tunnel is adjusted a metal ring filled with air, and provided with nozzles that project the latter into the tunnel.

The two cities of Liverpool and Birkenhead have for some time been connected by a steam railway that passes through a submarine tunnel. This latter has always been filled with smoke and soot, and the air of it has been irrespirable. The British Westinghouse Electric Company in order to obviate the difficulty has preferred to do away with steam traction and to substitute electric traction therefor.

It results from the observations made almost everywhere that by reason of the general increase in the requirements of a service that is more and more overburdened there will be reason in a near future to modify the present method of natural ventilation of

contact with oxygen. To this end, and also to insure the inflammability of the mixture, the powder is done up in colloid, whose products of combustion constitute a reducing atmosphere, adapted to the dissociation of the binoxide of barium at the lowest possible temperature. All the elements of such a powder thus play an active part at the highest point. These powders have besides a great advantage over those made of potassium chlorate; they are absolutely inexplodable by the stroke of a hammer, and are inodorous and without danger from the physiological point of view. M. Henry, we are told, has prepared two types of powder that differ in their proportions of the binoxide—the first, which has only a little magnesium, gives only 45 to 50 per cent of smoke, whereas ordinary powders give 75 to 90 per cent. The other is richer in magnesium, burns more slowly, and can be used advantageously only in a special lamp, when the proportion of smoke falls as low as 10 per cent, and the brilliancy, owing to the high temperature to which the magnesia is raised, is very great.

A BRIEF COMPARISON OF RECENT BATTLESHIP DESIGNS.

By NAVAL CONSTRUCTOR H. G. GILLMOR, U. S. N.

THERE is probably no class of design work in which what is to be done is so largely controlled by what has been done, and what is being done, as in the designing of naval vessels. The value of any vessel for naval purposes must necessarily be determined finally not only by the features embodied in the vessel itself, but by the characteristics of the vessels against which she may be opposed. It is this which makes the study of the development of foreign designs a necessity, and determines the characteristics of the vessels of the several classes which may at any time be in course of design.

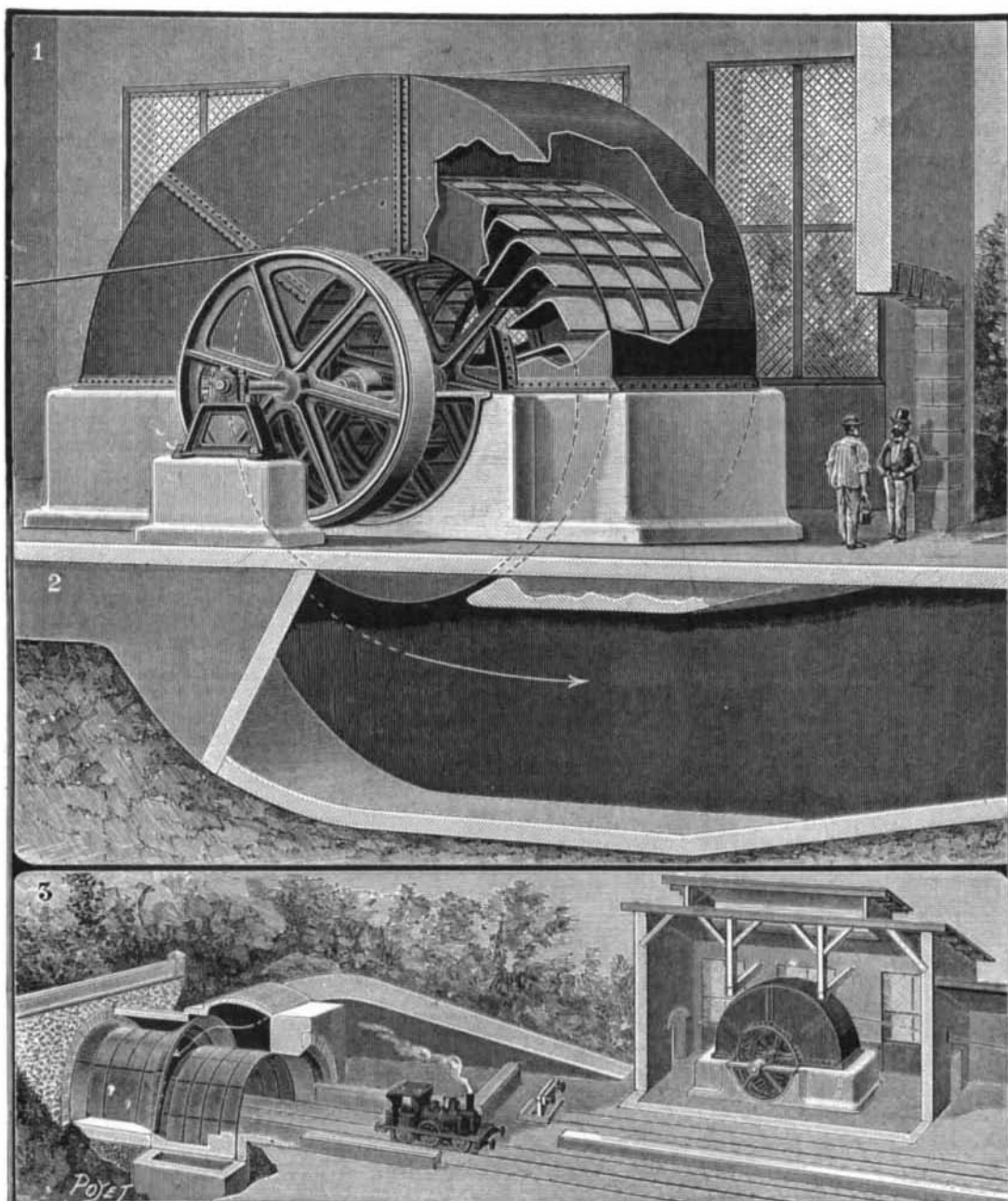
While from time to time new types of vessels have been introduced and developed, there has always been a type of vessel recognized in each period as the main strength and backbone of naval force; and this type has always been designated the battleship. It is to the consideration of the designs of vessels of this class of the present period that attention is asked. For the purposes of comparison there have been chosen the most recent designs of the several principal naval powers; and the comparison will be confined to the design conditions for those features which directly contribute to the naval value of each unit—that is to say, the armament, the protection, the speed, and the coal supply. The designs chosen are Great Britain, the "Duncan"; Germany, the "Wittelsbach"; Russia, the "Borodino"; Italy, the "Vittorio Emanuele"; Japan, the "Mikasa," and the United States, the "Virginia." In each case there are represented two or more vessels, the naval features of which are virtually the same as that of the vessel named. The information available with respect to the latest French battleship design is so meager as to have made it impracticable to include it in the comparison proposed.

In the engraving small-scale sketches, showing these vessels in elevation and deck plan, are given with the purpose of presenting visually the differences in naval features among them. Full data is given in the tabular statement in Table I. which follows.

Even to the casual observer considerable variation in the design features must be noticeable; and since this variation may be taken as an indication of the range within which designers of the present have considered it advisable to limit these elements, a brief notice of them may not be without value.

In armament, uniformity of practice is found in the location of the heavy guns, but in their number and caliber a considerable range is noticeable. With but two exceptions 12-inch guns have been chosen, and, with a single exception, the number of heavy guns is four, mounted in pairs, two forward and two aft. In the "Mikasa," four 10-inch guns make up the heavy battery, though in other vessels of practically the same general characteristics built for the Japanese government, 12-inch guns have been employed. In the "Wittelsbach" design, four 9.4-inch guns have been adopted, marking the limit in lightness of caliber of the first-caliber guns in battleships. The one exception to the number four for the heavy guns is in the "Vittorio Emanuele," where two 12-inch guns, mounted one forward and one aft, have been chosen. In the guns of second caliber an almost equal range in caliber and a considerable variation in arrangement are noticeable. In all but two of the designs under consideration what may be called a central battery, more or less extended, is employed. This central battery reaches the extreme of concentration on the "Wittelsbach," and is most extended on the "Virginia." In two out of the six designs the secondary caliber guns are mounted exclusively in such a central battery, with the addition of four guns of second caliber in isolated casemates, giving bow and stern fire. In two others, in addition to the central battery, a portion of the second caliber guns are mounted in turrets, giving fire over a considerable arc from directly ahead or directly astern. In these turrets there are, in one case, guns mounted in pairs, and, in the other, single guns. The "Borodino" and "Vittorio Emanuele" mount the second caliber guns entirely in such turrets. In the "Wittelsbach," the central battery, isolated casemates and turrets for the second-caliber guns, are used in combination. In the choice of a caliber for second-caliber guns, 8-inch guns and 6-inch guns divide honors. In the "Vittorio Emanuele" the second-caliber guns are 8-inch guns. In all the others, with the exception of the "Virginia," the second-caliber guns are 6-inch guns. In the "Virginia" both 8-inch and 6-inch guns are employed. The number of guns of second caliber varies from twelve 6-inch in the "Duncan" to twelve 6-inch and eight 8-inch in the "Virginia." In the secondary battery also there is considerable variation in the number and caliber of the guns, the arrangement being dependent upon the system employed in mounting the second-caliber guns. The caliber ranges from 15-pounders and 1-pounders in the "Wittelsbach" to 12-pounders and 3-pounders in the "Duncan"; and, in numbers, from forty in the "Borodino" to eighteen in the "Duncan."

In the matter of protection to stability by a water-line belt, a considerable range is noticeable. The lower limit is found in the "Duncan," in which two-thirds of



VENTILATION OF TUNNELS.

1. The Farcot Ventilator. 2. Ventilating tunnel. 3. General view of the installation.

happened that the renewal of the air was imperfectly effected, and that accidents were to be apprehended.

M. Saccardo, inspector-in-chief of the railways of Italy, devised the first system of ventilation, which was applied in what is called the "Apennine Tunnel," upon the line from Bologna to Pistoja.

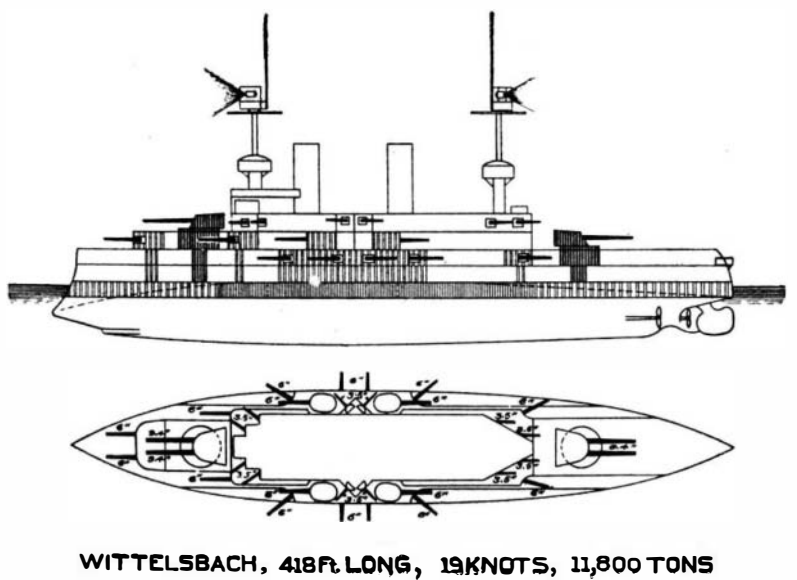
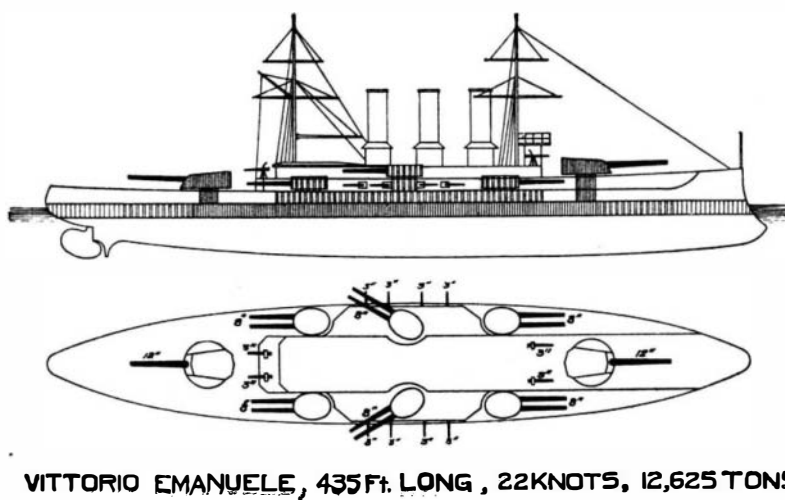
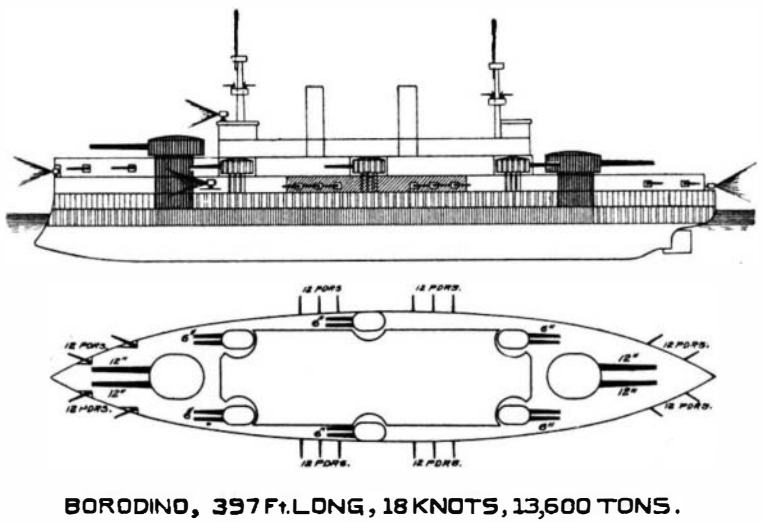
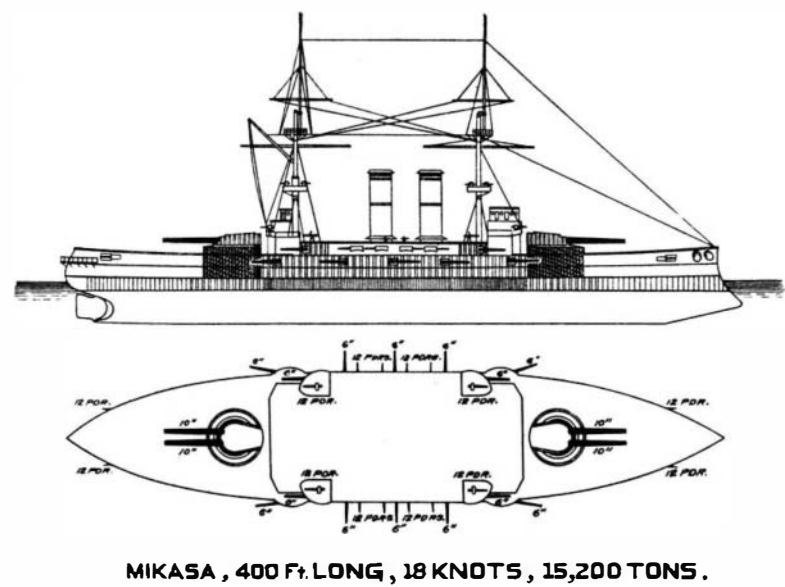
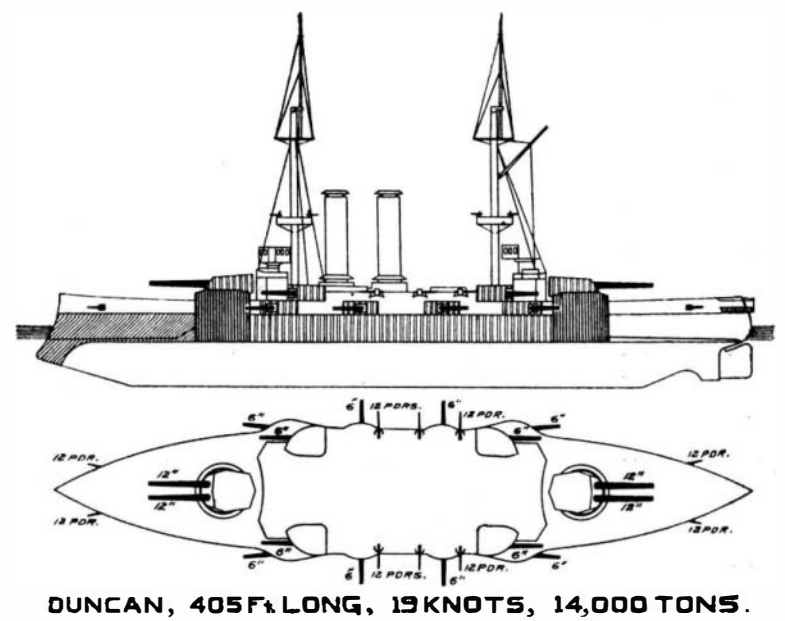
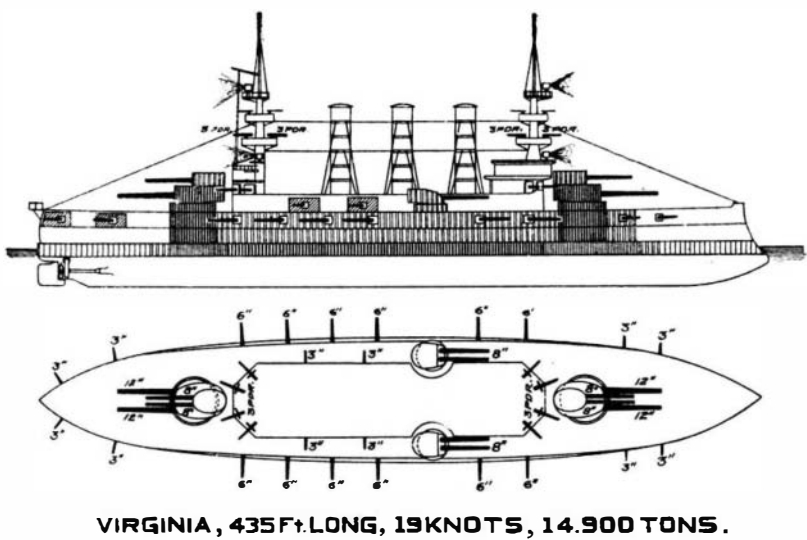
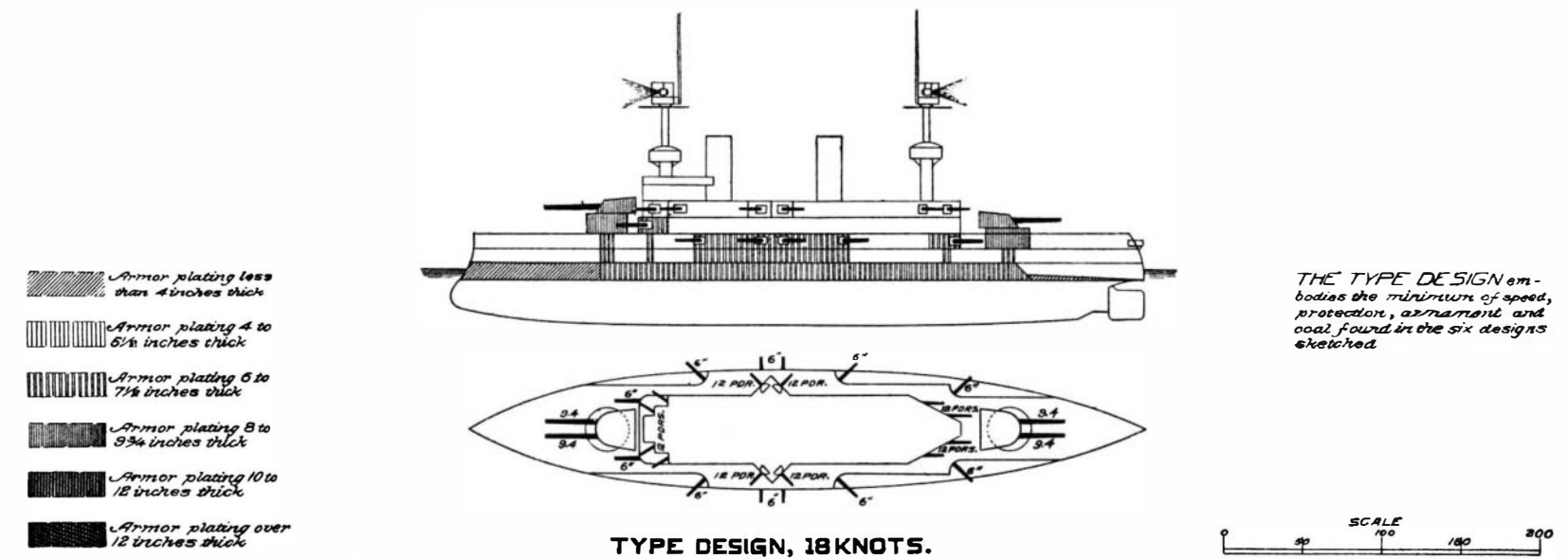
According to a paper by M. L. Champy, published in the Annales des Mines, the length of this tunnel is 16.4 miles, with a continuous gradient of 0.3 of an inch to the foot in a straight line with the exception of a curve of about 1,600 feet radius and a length of 1,300. It has a single track, and a section of 248 square feet, with a perimeter of 60.75 feet. It is in the center of a mountain, near a summit where violent winds often annul the current of natural air. The conditions of exploitation from the viewpoint of combustion and that of the personnel were of the worst character.

The Saccardo apparatus is installed at the uppermost orifice of the tunnel, and is so arranged as to direct the current of air against the ascending trains. It consists of an annular chamber placed at the head of the tunnel and connected with the gallery of a ventilator, and is prolonged into the tunnel in front. The external lateral walls are of masonry. The covering, the connection with the gallery and the internal lateral walls are of woodwork. The ventilator, which is of the Ser type, has a diameter of 16 feet. This installation has been submitted to a large number of experiments and its operation found to be satis-

long tunnels. It will become necessary to have recourse to mechanical ventilation to multiply, whenever possible, the number of draught chimneys, or, finally, to adopt electric traction for the traversing of tunnels if circumstances are favorable thereto.—For the above particulars and the illustration we are indebted to La Nature.

SMOKELESS FLASH-LIGHT.

THE magnesium flash-light powders commonly employed for photography make, as everyone knows, a very disagreeable cloud of smoke. M. Charles Henry has been experimenting with a view to doing away with this disagreeable feature. His results are communicated to La Photographie by M. L. P. Clerc, and are thus condensed in the Revue Scientifique: M. Charles Henry has endeavored to keep the magnesia that is formed as much as possible attached to a heavy substance that will not easily fly about, and falls soon by its own weight, namely, the binoxide of barium. This substance, at a red heat, gives up half of its oxygen, and its salts communicate to flames a brilliancy of greenish fire, which partially corrects the undue proportion of violet and ultra-violet rays emitted by incandescent magnesia. Finally the binoxide swells when heated, and becomes capable of retaining the light powder of magnesia formed in contact with it. The sole condition to be observed, that the binoxide may be reduced with incandescence, is to remove it vigorously from all



COMPARISON OF RECENT BATTLESHIP DESIGNS.

TABLE I.

	Virginia.	Duncan.	Borodino.	Mikasa.	Wittelsbach.	Vittorio Emanuele.	Type Design.
Laid down.....	1901	1899-00	1900	1899	1890-00	—	—
Length between perpen- diculars.....	435'	405'	397'	400'	418'	435'	435'
Breadth, moulded.....	76' 10"	75' 6"	76' 0"	76' 0"	68' 0"	73' 6"	76' 0"
Draught, mean.....	24' 0"	26' 6"	26' 0"	27' 2"	25' 0"	25' 7"	—
Displacement, in tons...	14,950	14,000	13,600	15,200	11,800	12,624	—
Indicated H. P. with forced draught.....	19,000	18,000	16,000	15,000	15,000	19,000	—
Speed, in knots, with forced draught.....	19.0	19.0	18.0	18.0	19.0	22.0	18.0
Boilers.....	Various.	Belleville.	Belleville.	Belleville.	Cyl. & Schultz.	—	—
Armament:							
Main battery.....	4-12" 8-8" 12-6"	4-12" 12-6"	4-12" 12-6"	4-10" 14-6" R. F.	4-9.4" 18-6" R. F.	2-12" 12-8"	4-9.4" 12-6"
Secondary battery....	12-3" 3-3 pdrs. 8-1 pdrs.	12-12 pdrs. 6-3 pdrs.	20-12 pdrs. 20-3 pdrs. 4 Maxim.	20-12 pdrs. 8-3 pdrs. 4-2½"	12-3.5" 12-1 pdrs.	12-3" 12-1.8"	12-12 pdrs. 6-3 pdrs.
Torpedo tubes:							
Above water.....	—	—	4	—	1	4	—
Submerged.....	2	4	2	4	5	—	2
Protective deck:							
Thickness of slopes...	3"	1"	2½"	2"	3"	4	3"
Thickness of horizon- tal parts.....	1½"	2"	1½"	—	1½"	2	1½"
Armor:							
Length of water-line belt.....	Whole length.	¾ length.	Whole length.	Whole length.	Whole length.	Whole length.	¾ length.
Breadth of water-line belt.....	8' 0"	7' 0"	6' 6"	7' 9"	7' 0"	—	7' 0"
Thickness of water- line belt, amidships.	11.8"	7"	8"	9"	8.8"	9¾"	7"
Thickness of water- line belt at ends....	4"	2"	5¾"	4"	4"	4"	2"
Bulkheads.....	6"	7"	—	6"	6"	6"	6"
Length of upper belt.	¾ length.	¾ length.	Whole length.	¾ length.	¼ length.	¾ length.	¼ length.
Width of upper belt..	—	7' 0"	5' 6"	7' 6"	7' 6"	7' 6"	7' 6"
Thickness, upper belt.	6"	7"	6.4"	6"	6"	6"	6"
Protection, largest guns.....	10"	11"	10"	14"	10"	8"	8"
Protection, medium caliber guns.....	6"	6"	6"	6"	6"	6"	6"
Protection, other guns	2"	—	3"	—	—	—	—
Conning tower, for- ward.....	9"	12"	—	14"	10"	10"	9"
Conning tower, after..	5"	3"	—	3"	6"	—	3"
Coal supply, normal...	900	900	900	1,400	650	1,000	650
Coal supply, bunkers full.	1,900	2,000	1,500	2,000	1,250	2,000	1,250

the length of the vessel is protected by a belt of a thickness of 7 inches, the forward end being protected from the fire of secondary battery guns by 2-inch nickel steel plating riveted upon the skin plating—as in protective decks. The remaining five vessels under consideration have, for stability protection, complete water-line belts, the maximum thickness of which is found in the "Virginia"—11 inches at top of armor amidships, tapering to 8 inches at the bottom. The lower limit in the extent of the upper belt, affording protection to the ammunition supply for the battery, is found in the "Wittelsbach," where this belt is limited to about one-fourth of the length of the vessel. Three of the vessels under consideration, namely, the "Virginia," the "Duncan," and the "Mikasa," carry this upper belt over about two-thirds of the length. The "Vittorio Emanuele" has an upper belt over somewhat more than one-third its length, and the "Borodino" for the whole length. It should be mentioned, however, that in the "Borodino" both the water-line belt and this upper belt are so narrow that the two combined really make a wide water-line belt over the whole length of the vessel. The thickness of the armor employed for this upper belt is uniformly 6 inches, except in the case of the "Duncan," in which the water-line belt and upper belt are continuous and 7-inch armor is employed.

In the character and extent of the protection to the guns of first caliber, the greatest range is noticeable. The lower limit of such protection is found in the "Vittorio Emanuele," where 8-inch armor is employed, and restricted armored tubes with walls of equal thickness, for protection to the ammunition supply. From this the degree of protection ranges upward, as may be readily observed from the figures in the engraving, the maximum being found in the "Mikasa," in which there are barbettes 14 inches in thickness extending at their full diameter to the top of the water-line belt.

The protection adopted for the guns of second caliber is uniformly 6-inch armor throughout all the designs under consideration. The method of disposing this armor for the protection of the guns varies. In three of the six ships there are central batteries, concentrated in the "Wittelsbach" and extended in the "Virginia" and "Mikasa." In addition to this central battery the "Wittelsbach" and "Mikasa" employ, also, isolated casemates with 6-inch armor for a portion of the guns of second caliber; and, in the "Duncan," this system of protection exclusively is employed for the second-caliber guns. Upon the "Vittorio Emanuele" and "Borodino," the second-caliber guns are all carried in armored turrets, with 6-inch armor, and, in the "Wittelsbach" and "Virginia," such turrets are combined with central batteries, or with central batteries and casemates. The exceptional features in protection and system of mounting in the superposition of 8-inch turrets upon 12-inch turrets in the "Virginia," have been the subject of so much discussion as to make special comment unnecessary. The "Borodino" and "Virginia" are the only vessels in which any protection is provided for guns of the secondary battery.

The speed adopted for two of the vessels is 18 knots. In the "Virginia," "Duncan," and "Wittelsbach," the

designed speed is 19 knots. In the "Vittorio Emanuele" the speed feature is developed to an extent which separates this vessel widely from the others under consideration. Her speed of 22 knots, if realized, would practically place her on an equal footing, as to speed, with the armored cruisers being constructed by several of the naval powers. There seems reason to doubt the accuracy of report as to the speed feature of this vessel, regard being given to the other features proposed.

The lower limit in the coal supply in the designed condition is found in the "Wittelsbach," the design of which provides for a normal supply of 650 tons, with a maximum stowage capacity of 1,250 tons. From this the normal coal supply ranges through 900 tons for the "Borodino," "Virginia," and "Duncan," 1,000 tons for "Vittorio Emanuele," to a maximum for this element of 1,400 tons in the "Mikasa."

The variations which have been pointed out make direct comparison of the several vessels difficult. To establish a basis for the present comparison, it is proposed to assume a vessel whose dimensions are those of the largest vessel under consideration, in which the features of armament, protection, speed, and coal supply embodied are the minima of these several features, which may be found among the designs under discussion. Such a vessel would represent the extreme limit to which, as judged from current practice, it is thought possible to reduce the several elements, and will be designated a *type design*.

This *type design* will then be a vessel of about 435 feet in length and 76 feet in breadth (about the extreme dimensions of the "Virginia" class), having a speed of 18 knots (the speed of the "Mikasa" and "Borodino"); with a normal coal supply of 650 tons (that of the "Wittelsbach"); a battery of four 9.4-inch guns (the first-caliber battery of the "Wittelsbach"), and twelve 6-inch guns, twelve 12-pounder and six 3-pounder guns (the second-caliber guns and secondary battery of the "Duncan"); two torpedo tubes (as in the "Virginia"); a water-line belt 7 inches thick and 7 feet wide, extending from the after barbette for two-thirds of the length of the vessel, with 2-inch nickel steel plating carried from the forward end of this belt to the stem (the water-line protection of the "Duncan"); surmounted by a shorter belt 6 inches in thickness, inclosed by bulkheads at its ends of the same thickness, extending up to the top of the gun deck to form a protected battery (as on the "Wittelsbach"); the 9.4-inch guns and ammunition supply protected by barbettes and ammunition tubes, carrying armor 8 inches in thickness (the protection of the first-caliber guns of the "Vittorio Emanuele"); and the 6-inch guns and ammunition supply protected by 6-inch armor (the protection of the second-caliber guns provided in all of the designs under consideration). It has been necessary to assume that the protective decks in the several designs under consideration are of practically equal value as protection, and that the type design has an equivalent protective deck. A sketch outline of the elevation and deck plan of this type design will be found at the top of the engraving, and detailed data relative to her several features, in the last column of the foregoing table, Table I.

To attempt to express in figures an absolute or relative naval value, even for vessels of the same class, is generally regarded as almost impracticable, because of the impossibility of suitably assigning values among the several design elements, all contributing to a successful whole and differing so widely in their individual purposes as to be practically incomparable. Since, however, such an expression of value, even if only very approximately correct, affords a means of giving point to a comparison, an effort will be made to reduce the present comparison to such terms as will permit the assignment of approximate relative values. The results, depending as they do upon so many things which, at best, can be but inaccurately known to any but the designer of each vessel, must, of course, be regarded as qualified by the inaccuracies in the data upon which such results depend.

It may fairly be assumed that the naval value of any vessel at a given period depends chiefly upon the battery carried; the protection given to stability, armament, ammunition supply and personnel; the speed; and the time during which she may operate without interruption, as measured by her coal supply. Her naval value, therefore, is independent of her displacement, although there is a relation between that naval value and displacement which fixes the limit of naval value which may be reached upon any displacement, and the excellence of any design should be judged by the nearness of the approach of that design to this limiting relation.

Such a vessel as the type design outlined above has, for naval purposes, a definite value, which might be expressed in a variety of ways. Each of the several vessels whose designs it is proposed to compare may be regarded as being such a vessel as the type design, upon which improvements of value have been introduced in one or more of the elements of armament, protection, speed, or coal supply. The designers of the several vessels under consideration, having provided for the minima of the several essential features of battleship design, have varied the distribution of the remaining disposable weight in a manner which each individually deemed most efficient. Since each of the several features may be found developed to an extreme in some one or more of the vessels being compared, and since the one restricting and governing condition in such development is weight, may it not fairly be assumed that the naval value, assignable to the excessive development of any one of the design features, may be represented by the weight necessary to such a development in any degree above that represented by a minimum embodied in all the designs. Such an assumption will here be made; and the naval value of the type design will be assumed to be 4,300, the approximate weight required, under the conditions outlined, to provide in the type design the features embodied. The relative naval value of each vessel under consideration, as compared with the type design, will be expressed finally by adding to 4,300, the naval value of the type design, the weight which it would be necessary to add to the type design in order to provide in that vessel for the armament, armor, speed, and coal carried in the design whose relative naval value it is desired to represent.

The several vessels, when compared with the type design, show increases in the several naval features, with corresponding added naval value as follows:

"VIRGINIA."

Four 12-inch guns instead of four 9.4-inch guns..	Value 160
Eight 8-inch guns additional.....	350
Twelve 14-pounders instead of twelve 12-pounders, and two 3-pounders and eight 1-pounders additional	40
Heavier and more extended water-line protection (11-inch armor as compared with 7-inch armor amidship)	410
More extended upper belt	120
Heavy guns in turrets protected by 10-inch armor; Large diameter barbettes with 10-inch armor	620
Protection of 8-inch gun positions, and extended central battery protection	240
Protection to portion of secondary battery.....	40
Additional normal coal supply	250
One knot more speed, which, with weights added above, necessitates increase in machinery weights	520
Total additional value	2750
Value of type design	4300
Relative naval value	7050

"DUNCAN."

Four 12-inch guns instead of four 9.4-inch guns..	Value 160
Two additional submerged torpedo tubes.....	20
More extended upper belt of greater thickness....	350
Heavy guns mounted on turn-tables with barbettes protected by 11-inch armor.....	500
All second caliber guns in isolated armored casemates, affording additional protection to such guns	260
Additional normal coal supply	250
One knot more speed, which, with the weights added above, necessitates increase in machinery weights	450
Total additional value	2000
Value of type design	4300
Relative naval value	6300

"BORODINO."

Four 12-inch guns instead of four 9.4-inch guns..	Value 160
Eight additional 12-pounders and fourteen additional 3-pounders	50
Four additional above water torpedo-tubes.....	30
Heavier and more extended water-line protection (9-inch armor as compared with 7-inch armor amidship)	100
More extended upper belt, complete	200
Heavy guns in turrets protected by 10-inch with large armored tubes	450
Protection to portion of secondary battery.....	120
Additional normal coal supply	250
With same speed, weights added necessitate increase in machinery weights.....	130
Total additional value.....	1490
Value of type design.....	4300
Relative naval value.....	5790

"MIKASA."

Four 10-inch guns instead of four 9.4-inch guns..	Value 50
Two additional 6-inch guns.....	50
Eight additional 12-pounders, two additional 3-pounders, and four additional 2½-pounders.....	20
Two additional submerged torpedo-tubes.....	20
Heavier and more extended water-line protection (9-inch armor as compared with 7-inch armor amidship)	350
More extended upper belt.....	190
Heavy guns mounted on protected turn-tables, with large diameter barbettes protected by 14-inch armor	580
More extended central battery and protection to two additional 6-inch guns.....	190
Additional normal coal supply.....	750

TABLE II.
TABLE OF RELATIVE, ADDITIONAL, AND TOTAL NAVAL VALUE.

	VIRGINIA.		MIKASA.		VITTORIO EMANUELE.		DUNCAN.		BORODINO.		WITTELSBACH.	
	Added value.	Totals.	Added value.	Totals.	Added value.	Totals.	Added value.	Totals.	Added value.	Totals.	Added value.	Totals.
Heavy guns and ammunition	160		50		—50		160		160		—	
Second caliber guns and ammunition	350		50		220		—		—		145	
Secondary battery guns and ammunition	40		20		20		—		50		10	
Torpedo outfit	—		20		30		30		30		25	
Total amount		550		140		220		190		240		180
Water-line protection	410		350		270		—		100		130	
Upper belt and bulkheads	120		190		80		350		200		—	
Protection to heavy guns	620		580		—		500		450		80	
Protection to second caliber guns	240		190		—160		260		—		240	
Protection to secondary battery	40		—		—		—		120		—	
Total protection		1,430		1,310		190		1,110		870		450
Coal supply	—	250	—	750	—	350	—	250	—	250	—	—
Speed	—	520	—	230	—	1,500	—	450	—	130	—	330
Total additional value		2,750		2,430		2,260		2,000		1,490		960
Value of type design	—	4,300	—	4,300	—	4,300	—	4,300	—	4,300	—	4,300
Relative naval value		7,050		6,730		6,560		6,300		5,790		5,260
Designed displacement	—	14,950	—	15,200	—	12,624	—	14,000	—	13,600	—	11,800
Efficiency of design	—	47.2	—	44.3	—	52.0	—	45.0	—	42.7	—	44.6

With same speed, weights added above necessitate increase in machinery weights..... Value 230
Total additional value..... 2430
Value of type design..... 4300
Relative naval value..... 6730

“WITTELSBACH.”

Six additional 6-inch guns Value 145
15-pounders instead of 12-pounders..... 10
Additional torpedo outfit..... 25
Heavier and more extended water-line protection (8.8-inch armor as compared with 7-inch armor amidship) 130
Additional protection to heavy guns (10-inch armor as compared with 8-inch armor) 80
Armored casemates for two additional 6-inch guns and turrets for four additional 6-inch guns..... 240
One knot more speed, which, with weights added above, necessitate increase in machinery weights 330
Total additional value..... 960
Value of type design..... 4300
Relative naval value..... 5260

“VITTORIO EMANUELE.”

Two 12-inch guns instead of four 9.4-inch guns.. Value 50
Twelve 8-inch guns instead of twelve 6-inch guns.. 220
Twelve 14-pounders instead of twelve 12-pounders, and six additional 3-pounders..... 20
Additional torpedo outfit..... 30
Heavier and more extended water-line protection (9.4-inch armor as compared with 7-inch armor amidship) 270
More extended upper belt..... 80
Protection to second-caliber guns by turrets..... 160
Additional normal coal supply 350
Four knots more speed, which, with weights added above, necessitate increase in machinery weights 1500
Total additional value..... 2260
Value of type design..... 4300
Relative naval value..... 6560

In Table II. the several vessels will be found in the order of their relative values, and the values assigned to each of the several items are given in such a manner as to facilitate direct comparison of the distribution of weight among the several features.

It should be noticed that there is reason to believe that the figures for the indicated horse-power and displacement for the Italian vessel, “Vittorio Emanuele,” are inaccurate, since, in the present state of shipbuilding art, it would seem to be impracticable to procure, with the horse power given, the designed speed of 22 knots in a vessel of the designed displacement of 12,624 tons; and this displacement would seem to be inconsistent with the features which, if report relative to this vessel be true, it is proposed to embody in the design. It should also be noticed that the feature of protection given by the protective decks of the several vessels is regarded as being of equal efficiency and value in all the vessels. It is known that in the “Borodino” this protective feature has been developed to an extent somewhat in excess of that found in the other vessels compared; and, had it been practicable to extend the comparison to include this feature, the “Borodino” would, doubtless, have shown to better advantage in the final results.

Since the relative naval values given above are expressed in terms of, mathematically, the same dimensions as those employed in the expression of displacement, if the relative naval values be divided by the designed displacements of the several vessels, the results may be expressed as a percentage, which might be termed the efficiencies of the several designs. These figures are given in the last line of Table II., and varying, as will be seen, from 42.7 per cent for the “Borodino,” up to 52 per cent in the “Vittorio Emanuele” (assuming the designed displacement given for this vessel to be a possible one); and the order of merit of the designs would be, on this basis, as follows:

- “Vittorio Emanuele,” 52.0.
- “Virginia,” 47.2.
- “Duncan,” 45.0.
- “Wittelsbach,” 44.6.
- “Mikasa,” 44.3.
- “Borodino,” 42.7.

In conclusion, it may be stated that while reasonable care has been given to the estimates upon which they are based, detailed accuracy in the figures given above is not claimed. The purpose has been to roughly estimate and express in concrete terms the relative naval values of the several vessels whose designs were consid-

ered, in order that the results of this comparison might be presented in a form more tangible than that of a general discussion of the several features of the designs.

HIGH-TENSION SWITCHES.*

By E. W. RICE.

It is evident that great advances in the capacity and voltage of generators would be useless, if not positively dangerous, unless adequate means for controlling and switching the electrical current were at hand. The evolution of the dynamo was for a time more rapid than that of the devices for controlling and switching currents of large volume and potential. As a result, a number of machines of large size were placed in operation with comparatively inadequate methods of switching and controlling. The energy and power which can be safely concentrated in a single central station is obviously limited by the amount of current and voltage which switching devices can safely handle. This fact was especially forced upon the attention of the writer at the time when the company with which he is connected took the contract for the equipment of the generating station of the Metropolitan Traction Company, New York. This station was to contain 11 three-phase dynamos, each of 3,500 kilowatts output at 6,600 volts. In order to realize the full economy of such a station, it was, of course, necessary that all the generators should supply current to a common bus bar, and that from these bus bars the current should be distributed through feeders to a number of sub-stations. The sub-stations were to contain rotary converters, frequently working in multiple with large storage batteries on the direct-current side. The characteristics of such a load prevented any reliance being placed upon the opening of the exciting circuit of the generators in case of the necessity of a general shutdown, as the rotary converters would, under certain conditions, supply sufficient magnetizing current to excite the generators, even with the field windings of the generators unexcited. It became, therefore, essential to produce a switching mechanism which would enable the generators to be connected and disconnected from the bus bars with certainty and safety under all conditions of load, even up to a short circuit, and also that the various feeders supplying the sub-station should be capable of the same treatment. Three types of switching devices were available for this work, and were carefully considered:

1. Switches breaking the circuit in the open air.
2. Switches arranged to break the circuit in an inclosed air space.
3. Switches arranged to break the circuit under oil.

Switches of the first type (open air) were impracticable, because the space demanded to make such switches operative could not be provided.

Switches of the second type (inclosed air) had no such limitation, but oil-break switches were found to meet the conditions more perfectly. Tests conducted showed that energy of 2,000 kilowatts to 3,000 kilowatts could be controlled in a single oil switch at potentials as high as 15,000 volts, which was the limit of the apparatus at our disposal at the time. Switches of this type, however, as large as were considered necessary, required an amount of oil per switch so great as to be objectionable, in view of the large number of switches required for generators and feeders. The problem, then, was to produce a switch which would retain all the advantages of the usual oil-switch, and at the same time minimize the quantity of oil. The type which was finally evolved and employed in the Metropolitan installation has shown itself in practice to be remarkably successful. It is known as the form “H” oil switch by the manufacturers, and was designed by the writer, with the assistance of Mr. E. M. Hewlett.

The switch, as designed for three-phase circuits, consists of three double-pole single-phase switches or elements. Each single-phase switch is contained in a fireproof cell, but all three switches are designed to be operated simultaneously. Each single-phase element consists of two brass cylinders or cans, one can for each pole. The incoming lead is attached to one of the cans and the outgoing

* Abstract of a paper read before the American Institute of Electrical Engineers.—From The Electrician.

lead of the same phase to the other. Each cylinder is nearly filled with oil and is covered by a metal cap, which carries a long insulating sleeve. Two copper rods joined by a metallic cross-head and forming together a U-shaped conductor, slide through the insulating sleeve and fit into tubular contacts at the bottom of the cans when closing the circuit. The cross-head of each U-shaped conductor is attached to a wooden rod, which extends through the top of the cell or casing which incloses the switch, and is in turn attached to a metal cross-head operated by an air motor or an electric motor, as the case may be. The three phases are seen, therefore, to be broken or closed simultaneously. When the three sets of U-shaped conductors are lifted the circuit is broken under the oil at two points in each phase, or six points in each complete three-phase switch. The range of movement of the cross-head varies with the potential to be controlled; it is 12 inches in the switches in the Metropolitan station for 6,000 volts, and 17 inches in the switches for the Manhattan station for 12,000 volts. The brass cans are lined internally with fiber to prevent the arc from jumping from the rod to the metal of the can when it is drawn up through the oil. Each switch unit stands alone on its own foundation, with the three phases in three separate cells or spaces separated by brick walls. These brick partitions act as barriers and prevent any possible burn-out in one cell from spreading to the others. As an opening of two legs breaks a three-phase line, an arc in one cell will not incapacitate the switch. The circuit-breaker or switch differs radically from older forms in the separation of the phases as indicated, and also in the separation of the contacts for each phase, in two separate oil pots. This separation of the terminals of each phase gives two separate arcs, each inclosed in a space well removed from the others, so that the possibility of an arc communicating from one pole to another is obviated. It will be seen that in breaking a three-phase circuit the arc is produced in six independent oil pots. This method of construction, together with the separation of the phases in separate fireproof compartments, accounts for the unusual effectiveness of the switch in practical operation.

It was at first thought that the use of oil switches for the control of high potential circuits would possibly result in resonance effects, particularly in circuits containing considerable capacity, such as underground cables or long overhead lines. A number of experiments have been conducted, and the weight of evidence seems to be in favor of the oil switch as avoiding these effects. It is an interesting fact that under the conditions described considerable disturbance due to resonance may occur upon the closing of a circuit. This is naturally independent of the character of the switch employed; it may occur equally well with an oil, an inclosed air, or an open-air switch. Upon the rupture of the circuit, however, the results obtained from many tests indicate that open-air switches are liable to produce heavy resonance effects while the inclosed air and the oil switch are practically free from such effects. Extensive experiments to determine this point were conducted prior to the production of the switches for the Metropolitan and Manhattan stations. Very recently experiments of a more severe character have been conducted at Kalamazoo, Mich. These tests were made at from 25,000 to 40,000 volts, with from 1,200 to 1,300 kilovolt amperes of highly inductive load, the power factor being 40 to 60 per cent. The switches tested were the cylindrical oil switch, already described (Metropolitan type); an oil switch in which all the terminals were inclosed in a single tank of oil, called the tank oil switch; a switch of the expulsion air-tube type; and an open-air switch in which the terminals were simply separated long distances in free air. In making these tests an oscillograph was used to determine the time of break and other interesting effects, and a camera to photograph any particular instructive phenomena.

The long-break open-air switch, which operates upon the principle of drawing a long arc in the open air, opened the circuit at 25,000 volts, but required several seconds of time, and drew such a long arc as to be impracticable. At 40,000 volts the arc held and flared to a total distance of over 30 feet until it struck the line and short-circuited the system, producing at the same time high-voltage oscillations equal to two or three times the normal potential of the system. It would, therefore, seem that the open-air switch was generally unsuitable for the control of high voltage systems of large power, as even where sufficient room is available for their use the production of high resonance effects tends to endanger the system. These tests also show that wherever a short-circuiting arc occurred in the open air, electric oscillations of high voltage resulted. These were probably due to the rapid alternate extinguishment and formation of the arc during its period of interruption, the arc acting somewhat in the manner of a Wehnelt interrupting device. The expulsion-tube air switch operated up to 25,000 volts, but failed at 40,000. The tank oil switch operated satisfactorily on 1,200 to 1,300 kilovolt amperes up to 25,000 volts, but at 40,000 volts it spat fire and occasionally emitted black smoke, thus seeming to be working at the limit of its capacity. No attempt was made to open short circuits with the tank oil switch. The cellular oil switch never failed to open 1,200 to 1,800 kilovolt amperes at any voltage up to the maximum employed—40,000; the circuit opening noiselessly and without the appearance of fire or emission of smoke at the switch. It was used as an emergency switch in all the tests to open short circuits on 25,000 to 40,000 volts. The results of these and other tests, and the continued effective operation of the cellular type switch in the Metropolitan station indicate that this type of oil switch will safely control circuits of practically unlimited power at potentials considerably above 40,000 volts, probably as high as 100,000 volts. The character of the break when operating properly was the same in all the switches except the open-air type. In opening, the arc held for a number of half waves from 6 to 18 and then broke at zero value without disturbance of the system. With the oil switches no traces of oscillation were noticed before the break, and no traces of rise of voltage. With the expulsion air switch traces of oscillation were seen for a number of half waves before the final break, and in consequence a slight voltage rise occurred.