almost incredible. A young woman of twenty-two who had lost sight and hearing at the age of six listened rapturously to the sounds of musical instruments and the human voice, conveyed to her for the first time since her affliction, by the new instruments. A boy student of the New York Deaf and Dumb Institution, who although deaf, had been taught to speak by watching the lips of others, repeated the words "papa," "mama," and "hello," after he had heard them with the aid of the apparatus, much to his own astonishment. A girl, born blind, deaf, and dumb, clapped her hands in ecstasy, when she heard herself utter "mama," and wistfully reached out toward the piano when the musician stopped playing and she no longer heard the harmonies that had thrilled her. Similar examples could be multiplied almost without end, for the instruments have been used on thousands of deaf and partially deaf persons.

After having witnessed so impressive a demonstration, one comes away with the idea that after all no one, except the man whose auditory nerve is paralyzed, is totally deaf. Many of those whom we are accustomed to regard as deaf are only partially deaf. The essential parts of the auditory apparatus are still present. It is only the subsidiary parts that are missing or defective. Your deaf mute, so called, is really not in need of an instrument which will amplify sound enormously. What he really needs is something to take the place of the missing or defective parts of his ear. And this is the result which has been attained in some of the instruments devised by Mr. Hutchison. In order to comprehend clearly what his apparatus really does it is necessary briefly to outline the structure and functions of the human ear.

The ear may be considered as composed of three parts—the external, the middle, and the internal ear. The visible ear is the external ear. It extends inwardly to the ear drum. Here begins the middle ear, which may well be regarded as a cavity filled with air. This air-filled cavity contains the ossicles—a chain of three small bones, connected together and extended across to the entrance of the internal ear. Of these small bones, the first is attached to the ear-drum; and the last to a membrane in the entrance of the inner ear, called the "oval window." Beyond this window lies a column of liquid in which float some three thousand nerve terminals, which, on their route to the brain, are wound together into a cable, which is known as the auditory nerve. If this nerve be affected to such an extent that deafness results, hearing can not be restored, any more than a man whose optical nerve is affected can be made to see. Sound agitates the column of liquid with more or less violence, depending upon the volume and pitch of the sound, and other circumstances. Each of the three thousand nerve terminals selects its proper sound and conveys it to the brain by means of the auditory nerve. Acoustic vibrations will not pass from a gas to a liquid without the assistance of some intervening medium of translation. The atmosphere through which we talk is a gas; the internal ear is filled with a liquid. It is the function of the ear-drum and the small bones to take up the sound waves from the air, to translate them into mechanical movement in order that the liquid of the internal ear may be properly excited. Sound, conveyed by the atmosphere to the ear, causes the ear-drum to vibrate. The vibrations of the drum are communicated to the chain of small bones, which, as they move, cause the oval window to pulsate, and hence the ear liquid to wash back and forth. Then the nerve terminals and auditory nerve are excited.

It is the purpose of one of Mr. Hutchison's instruments (the "acousticon") to take the place of the middle ear. The "acousticon" is the outcome of a prior instrument, called the "akouphone," which has been abandoned for the reason that the new instrument better answers the purpose of transmitting articulate sound to the inner ear. Since important patents are pending on the "acousticon" we are able only meagerly to describe the principle of its construction.

The "acousticon" may broadly be considered a combined telephone and microphone. The principle underlying the construction of the mouth and ear piece is well shown in one of the accompanying diagrams.

The essential feature of the invention is a cup-shaped body, into the open end of which the sound-waves enter, the bottom or inner end of the body being shaped to reflect and concentrate the sound-waves and finally direct them backward until they strike the center of a vibrating diaphragm mounted in the cup at right angles to its axis.

Besides the merit of compactness, the device is distinguished by the fact that there can never occur that interference of reflected sound waves which is so grave a drawback to the use of tubes, trumpets, and horns. In addition to the mouth and ear pieces, an exceedingly small but powerful storage battery, so small indeed, that it can be slipped into the coat pocket, is employed.

It is one of the peculiarities of the "acousticon" that the articulation of the spoken words is magnified, and not so much their sound-volume. In other words, the instrument talks inversely. A deaf mute who has never heard sound must learn not only to know what sound is, but, what is of more importance, must learn the meaning of different articulations. For that reason the "acousticon" has been designed not to amplify sound-volumes, but to emphasize articulation by magnification. So admirably has this result been accomplished that even a faint whisper is clearly heard by the deaf mute.

The "acousticon" is not intended for indiscriminate use by the deaf. The art of hearing must first be taught. And for this purpose an instruction outfit has been devised, which, since it is not intended to be carried about by the deaf mute, is of more pretentious appearance and size than the "acousticon." The mouthpiece and the earpiece of this instruction outfit are each provided with a nosepiece by which the nasal sounds, which by other instruments are either lost or only partially transmitted to the ear, are wholly conveyed to the earpiece. The nosepiece serves the subsidiary purpose of preventing the pupil from watching the movements of the lips; for many deaf mutes are wonderfully skillful lip-readers. Instruction in the art of hearing is of far more importance than may be imagined. The normal man has the faculty of eliminating sound and of concentrating his sense of hearing on one particular sound. To such an extent is this faculty sometimes developed that an experienced telegraph operator can translate the message sent or received by a single telegraph instrument, despite the incessant ticking of a hundred others in the same room. On the other hand, the deaf man who has either never heard at all or has forgotten how to hear, does not possess this power of elimination and concentration. If the "acousticon" were allowed to convey the sounds of the outer world to him he would hear so much that it may be said he hears nothing, paradoxical as that may seem. In other words, he hears not only the sound of the human voice upon which his mind ought to be bent, but also the rattling of wagons in the street, the walking of persons in the room, and the many sounds which we have all become so accustomed to that we no longer heed them. Practice is necessary before the deaf man can eliminate sounds he does not wish to notice. And this practice he acquires by means of the instruction apparatus in the hands of a competent teacher of deaf mutes. By means of this apparatus he not only learns what articulate sound is, but also acquires a feeling for vocal inflection. Many deaf mutes, although they can not hear, have been taught to speak. Unable to hear, however, their utterances are almost inflectionless, hard, and unmelodious. The instruction outfit enables them to learn something of the nature of pitch and inflection. After the pupil learns to speak properly, a special "acousticon" is provided for him, just as special lenses are prescribed for the eye.

Here two ingenious modifications of the "acousticon" should be briefly referred to—the one a portable outfit for the collection of sounds in concert halls and theaters, the other a desk outfit. The first of these, which may be termed the opera outfit, consists of a double sound-receiving instrument contained within a small box, and has been used with marked success by deaf mutes in listening to orchestral music. Indeed, so sensitive is the device that spoken words can be heard by the deaf at a distance of twenty-five feet and more. With this instrument, the previously mentioned girl who had lost both sight and hearing at the age of seven, was able to enjoy the music at the opera in New York city, as if she had never been stricken. The desk outfit mentioned comprises a collector of sounds, of parabolic cup-shaped form, by which the sounds are amplified for hearing with a regular "acousticon" earpiece. This earpiece is hung upon a hooked switch-arm, which, when the earpiece is removed, automatically turns on the battery current. The speaker talks in the ordinary way, in his usual conversational tone, without placing the mouth to any instrument. The hearer uses only the earpiece, which is so small that it seems as if he were holding his hand to his ear in order to catch the spoken words more easily, just as every one who is hard of hearing naturally does.

Another instrument invented by Mr. Hutchison is the "massacon," to be used for phono-electrically massaging the ear in cases of deafness resulting from catarrh. Probably 65 per cent of those who are deaf or hard of hearing may safely attribute their affliction to catarrh, associated with after-acquired secondary troubles. The "massacon" is not a device to enable the deaf to hear, but a contrivance for producing sharp impinging sounds to exercise the enervated and disused middle ear and adjacent parts. It is not an instrument to be carried on the person, like the "acousticon," but to be used by physicians only, at whose discretion it may be prescribed for individual use by the patient. It has been stated that the middle ear is an air-cavity in which the three small bones or ossicles are contained. The air enters the middle ear through the Eustachian tube, extending to the ear from the nasal cavity. The Eustachian tube is lined with mucous membrane; so is the middle ear cavity. The small bones of the middle ear are covered with mucous membrane. Catarrh starts from the nose and creeps gradually through the Eustachian tube to the middle ear cavity. It spreads over the walls of this cavity and finally attacks the small bones, inclosing them in a firm anchylosis and binding them at the joints so firmly together that they can no longer move individually to transmit sound from the ear drum to the internal ear. Deafness results, varying in degree, with the anchylosis. Inaction, due to catarrh, enervates the auditory apparatus. As any muscle of the body refuses to respond to the will after long disuse, so the ear, rendered inactive by catarrh, refuses to respond to sound. The "massacon," by massaging the small bones, restores to them their old vigor and sufficiently eradicates the effects of the catarrh so as to restore lost hearing, at least partially, and often fully.

The principle of the "massacon" is simple enough. A diaphragm, contained in the earpiece, is caused to vibrate by means of an electromagnet with any desired rapidity. When the earpiece is held to the external ear, the vibrations are transmitted directly to the ossicles. Such is the nicety with which the instrument can be adjusted, that a movement in the small bones is produced, exactly equal to that incurred when they normally transmit sound waves. The parts thus stimulated soon regain most of their old activity.

A COMPARISON OF THE GERMAN BATTLESHIP "WETTIN" WITH THE "MAINE."

BY FRED T. JANE.

The "Wettin" is one of five sisters of the "Wittelsbach" class—"Wittelsbach," "Wettin," "Zaehringen," "Mecklenburg," and "Schwaben." Most are now in commission, or if not thus far advanced, at least available should Germany need them.

In the matter of date and conception the "Wittelsbach" class corresponds to the U. S. S. "Maine" class. Though they do not equal the American vessels in displacement they nevertheless represent much the same idea, the increased size of the "Maines" being largely due to the fact that they are given a superior radius of action—a strategical advantage. Neglecting this strategical quality for the present, we may compare the "Maine" and "Wettin" as two different methods of disposing of certain tactical qualities. The extra tons of coal carried by the "Maine," together with other weights, may be held to balance her superior weight in such a matter as displacement.

With this preamble we may now tabulate the two designs against each other. There are, unfortunately, no other foreign ships of the same date and size, British ships running to 14,000 or more, the French "Suffren" to 12,728, and the Russian "Kniaz P. Tavritchesky" is, so far as can be ascertained, simply a copy of the "Maine" with minor alterations.

Now, looking at the above comparisons, the first point of note is the difference in proportions, the "Wittelsbach" being a much narrower ship than the "Maine." This means that she should be relatively less handy. Since, however, her deadwood aft is very much cut away while that of the "Maine" is only so treated to a less degree, the tactical diameters do not greatly differ. This relative narrowness enables the "Wittelsbach" to do with 14,000 I. H. P. what the "Maine" requires 16,000 to accomplish; but on the other hand this extreme deadwood cutting in German ships causes structural weaknesses, displayed when the ships are docked unless the greatest care is taken in arranging the blocks. The 5½ feet extra beam of the "Maine" does not look much, but coupled with her lesser length is relatively of considerable importance, and she should be by far the steadier ship of the two in a gale. She is, in fine, far better fitted to cross over to Europe than the "Wittelsbach" is to go over to America—though neither vessel, perhaps, is eminently suited to such a task. Ability to go a long voyage and fight at the end of it is the characteristic of British battleships rather than of those of any other power, and it is secured at the cost of putting an armament decidedly inferior to the "Maine's" into a ship nearly three thousand tons larger. It is a heavy price—one that may hardly be worth paying for any other nation. It is evidently not so considered by Germany, whose ships are alternately believed to be destined to try conclusions with those of the United States and England. Compelled to adopt moderate dimensions by the shallow nature of their waters, the Germans have put their money on tactical features and let the strategical ones go. This, seeing that any great degree of excellence in both qualities on moderate dimensions is impossible, seems the wiser course, though curiously enough the one and only watchword of the German navy is: "Attack. Be the odds ever so great the German fleet must always assume the offensive." Regarded as a doctrine *pur et simple* it is an excellent doctrine, but so far as Germany is concerned, many of her ships coast defenders, all of small coal supply, it seems a little suggestive of knocking heads against a brick wall. The "Wettin" and her sisters can indeed cross the herring-pond at economical speed, but they would arrive with depleted bunkers—the worst pos-

	WITTELSBACH class	MAINE class	K. P. TAVRITCHESKY	SUFFREN
Name		U. S. A.	Russian	French
Nation	German	1900	1900	1901
Launch	1900-01	12,300	12,500	12,728
Displacement	11,800 m. t.	394	371	410
Length (over all)	416½	72½	72 feet, 4 inches	70
Beam	67	24 mean	27	27 feet, 6 inches
Draught	28 full	Four 12-inch	Four 12-inch	Four 12-inch
Guns, A				
B	Four 9.4-inch			
C				
D	Eighteen 6-inch	Sixteen 6-inch	Sixteen 6-inch	Ten 6.4 inch
E				Eight 4-inch
F	Twelve 3.4-inch	Six 14-pounders	Fourteen 12-pounders	
lesser	Twelve 1-pounders	8 3-pdrs., 8 1-pdrs., etc.	Twenty 1 pounders	20 3-pdrs., 2 1-pdrs.
Machine, etc	8	6		
Torpedo tubes, sub.	5	2	8	2
Torpedo tubes, above-water (armored)	1		2	2
Belt, amidships	9 inches	12 inches	9 inches	12 inches
Belt, bow	4 inches	4 inches	none	6 inches
Belt, stern	4 inches	none (but 4-inch deck)	none	6 inches
Armor deck	3 inches	3 inches	4 inches	3 inches flat
Bulkhead	6 inches	10 inches	9 inches	
Turrets	10 inches	12 inches	12 inches	10 inches
Turret bases	10 inches	12 inches and 8 inches	10 inches	12 inches
Lower deck side	5½ inches	6 inches	6 inches	5 inches and 2 inches
Battery	5½ inches	6 inches	5 inches	6 inches
Small turrets	6 inches	none	none	5 inches
Casemates	5½ inches	6 inches	5 inches	none
Conning tower	10 inches		10 inches	
I. H. P	14,000	16,000	10,600	16,200
Maximum speed	18 knots	18 knots	17.5 knots	18 knots
Screws	2	2	2	3
Normal coal, tons	650	1,000	670	820
Maximum coal, tons	1,400	2,000	870	1150
Oil, tons	200		600	as required
Boilers	Thornycroft & cylindrical	Thornycroft	Belleville	Niclausse

sible condition in which to fight a battle. Those who followed the war-game war in the SCIENTIFIC AMERICAN SUPPLEMENT will remember how this difficulty operated. No German ships attempted to cross the Atlantic until, by a diversion in the Far East, all the seagoing American battleships had been drawn away.

German construction and German war theories do not, therefore, march hand in hand so far as operations against America are concerned—or at any rate not up to and including the "Wittelsbach" class. With later ships there is a difference. But of this another time.

As remarked above, in the "Wittelsbach" type, everything has been sacrificed for line-of-battle qualities—that is to say, guns and armor, for her speed is that of nearly all battleships now-a-days. As compared with the "Maine" guns, there is perhaps little to choose between four 9.4's and eighteen 6-inch against four 12-inch and sixteen 6-inch. Greater as is the penetration of the 12-inch gun, in these days of capped shell the 9.4 is good enough for direct impact against any armor at any range, while, if hitting at an angle be considered, both guns are likely enough to fail against the usual belt.

The failure of the "Wittelsbach" type lies in the amateurish disposition of the guns. She is emphatically a "paper" design, everything being secondary to a fancy end-on fire. She bears eight 6-inch ahead where the "Maine" brings but four. But those four in the "Maine" can all blaze away without interfering with other guns. The eight of the "Wittelsbach" can perhaps do that, but they certainly cannot avoid being interfered with. The back fire of the 9.4's must affect the casemates underneath. In target practice both need not fire together, but in battle they will have to. The same thing to some extent may apply to the "Maine's" forward casemates, but these, unhappily disposed though they may be, are very differently placed to the corresponding German guns. All through in the matter of her 6-inch the "Wittelsbach" suggests a lack of consideration of practical points. For instance, the four battery guns that have no axial fire are nested in those curious inward curves that were invented so long ago as the seventies when the Austrian "Tegetthoff" was designed. Then they served the purpose of a sponson without its defects, for they allowed a large arc of training and did not project to catch seas. To-day, they can but serve as traps to burst high explosives and insure the maximum effect, for there is little glance-off with a high-explosive shell. The base may glance away, or start to do so, but the detonation is by then accomplished. The blast, confined by the shape of the walls, is likely to spend much of its effort on the port-hole, kill the men inside and lift the gun off its bearings. An outward curve would greatly mitigate this.

In this matter the "Maine's" port-holes are not much happier. The fall-in of them, though differing from the "Wittelsbach's," is likely to have the same result. The "Maine," however, is free from the small turrets, four of which occupy the "Wittelsbach's" upper deck amidships. Shell-fire is sure to jam these at once, and a gun that cannot train on to the enemy is as good as a gun destroyed. It is no unreasonable surmise that in the first five minutes of action a "Wittelsbach" will, of the nine guns on her broadside, be minus one or both the forward ones from the blast of the big guns over them, minus both the small turrets from jams, and very probably one at least of the broadside guns fitted with "shell-traps." This is exclusive of what big-gun fire may do. All told, therefore, the arrangement of the "Wittelsbach's" secondary battery is by no means ideal; but there is no question but that she should be able to pour in a tremendous fire at the beginning of an action, if the Krupp guns are able to maintain anything like their nominal rate of fire, which is, to say the least, doubtful, despite the fact that the German gunner is a good man. Indeed, it is on the efficiency of the personnel that Germany has to rely rather than on the efficiency of her designs.

In the matter of armor, so far as weight is concerned, the German ship carries more than the American one—4,000 tons against 3,533. Allowing for meter tonnage, this means that the German ship has about 400 tons more placed on her. (How and where this difference comes is rather difficult to make out.) The "Wittelsbach" has a main belt 183 feet long by 7½ feet high by 9 inches thick. So far as can be ascertained it is of a continuous thickness, both laterally and vertically. The corresponding belt in the "Maine" is 200 feet long, 12 inches in maximum thickness, thinning somewhat at the ends and reducing to 7½ inches on the lower strake. It is of about the same width as that of the "Wittelsbach," and can certainly be no lighter. A 4-inch belt extends from the end of the main belt to the bow in both ships; in the "Wittelsbach" it goes to the stern also, whereas in the "Maine" it stops short at the after barbette. Both ships have 3-inch decks, the approximate weights being 600 tons in both cases. The "Wittelsbach's" is perhaps a little less, as the "Maine's" is thickened to four inches aft. It is certainly not heavier than the "Maine's."

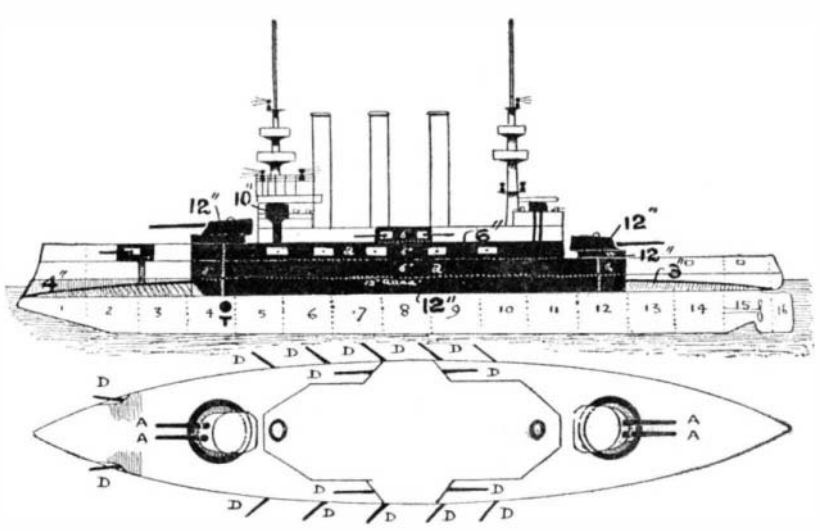
In the upper belt, 183 feet long in the "Wittelsbach," 200 feet long in the "Maine," the American vessel has half an inch greater thickness, and the same on the battery, which is only some 120 feet in the German ship, against 200 feet in the "Maine." In the protection to upper deck guns weights must be fairly equal. The "Wittelsbach" has two extra guns to protect and four are in turrets which weigh more than casemates. But since the 6-inch gun casemate weighs something less than 25 tons, the 400 tons difference is not made up here.

In the big gun turrets and barbettes the average thickness appears to be the same, the "Wittelsbach" having a general ten inches, the "Maine" a maximum of twelve to a minimum of eight. The barbettes both forward and aft are about seven feet higher in the German than in the American, and here no doubt extra weight is consumed. But as will be seen from the plan, the "Wittelsbach's" fore barbette does not descend to the protective deck—a weak point—and some saving of weight must be effected here. All told therefore it is not easy to see where the "Wittelsbach" consumes her extra 400 tons. Indeed, one is tempted to think that the official 4,000 tons is merely an estimate in round numbers dating perhaps from the days when the "Wittelsbach" was to have been a 12,000-ton ship. There is a rule-of-thumb approximation for German weights: One-third armor; one-third hull, fittings, etc.; one-third armament, ammunition, machinery, coal, etc. Probably it never pretended to be exact.

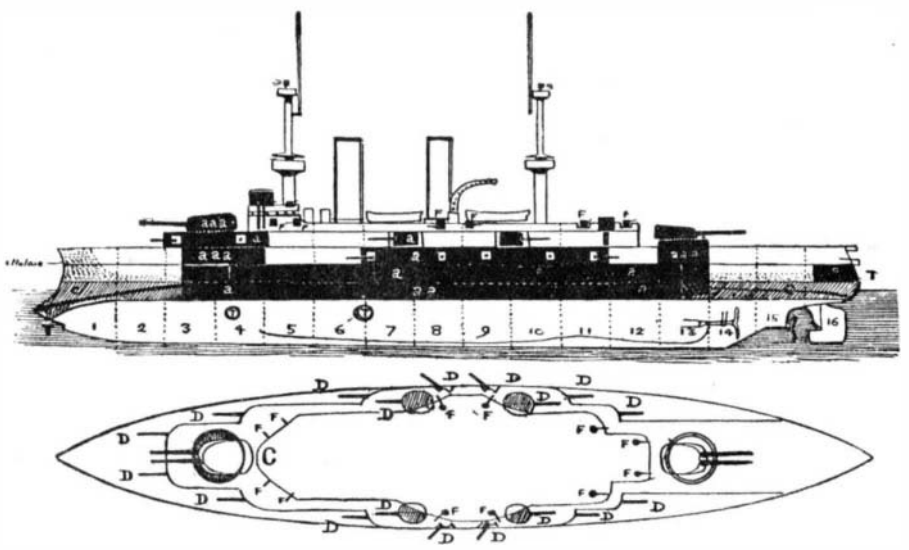
The weights of the "Wittelsbach" are mostly not to be procured, so they can only be approximately estimated against the "Maine's."

For what the comparison is worth it runs:

	"Wittelsbach." Meter tons.	"Maine." Tons.
Armor and deck	4,000	3,533
Coal (normal and oil)	950	1,000
Armament and ammunition*	941	1,058
Machinery and water*	1,400	1,396
Outfit, stores, equipment*	860	677
Hull.....say	3,649	4,836
	11,800	12,500



GUN AND ARMOR DIAGRAM OF BATTLESHIP "MAINE" AND CLASS.



GUN AND ARMOR DIAGRAM OF BATTLESHIP "WITTELSBACH" AND CLASS.

Those figures marked with an asterisk are taken from the "Kaiser Friedrich," which carries exactly the same armament, and cannot certainly have heavier machinery, for she is a smaller ship. It is said that the "Wittelsbach's" machinery is relatively lighter, so the weight estimated above is probably approximately accurate. Stores, etc., may have been reduced a little below the "Kaiser Friedrich" standard, but they cannot have been greatly so. The hull of that ship, which is of 11,150 tons displacement, weighs 3,500 tons.

It will be seen, then, that the "Wittelsbach's" chief score over the "Maine" is in weight of hull. Now the "Maine" has a relatively light hull—too light, some have said. The recent trouble with her on the gun trials indicates that there has been no prodigality in giving her strength. The "Wittelsbach" must be a good deal weaker. All experience would suggest that she is unduly and dangerously weak. We hear a good deal about the excellence of the work put into German warships, and there is a good deal of truth in it; but—no German ship has yet been in battle or even severely tried in a gale. Till one or two have survived these ordeals the impression will prevail that the German designers have cut things too fine and tried to get too much into a quart pot.

In conclusion, attention may be drawn to the "Wittelsbach's" excellent torpedo armament, two submerged tubes on the broadside, two trained 45 degrees abaft the beam and one in the bow, also an armored above-water tube aft. The "Maine" cuts a poor figure beside her here, and the smallness of her torpedo armament may well prove fatal in an engagement.

A word may be said, however, about her extremely short main belt. Under the barbettes there is only 4-inch armor, which any high-explosive shell will shatter. Water-line hits are likely to be rare in action, but if the ship does get hit here considerable trouble is likely to result.

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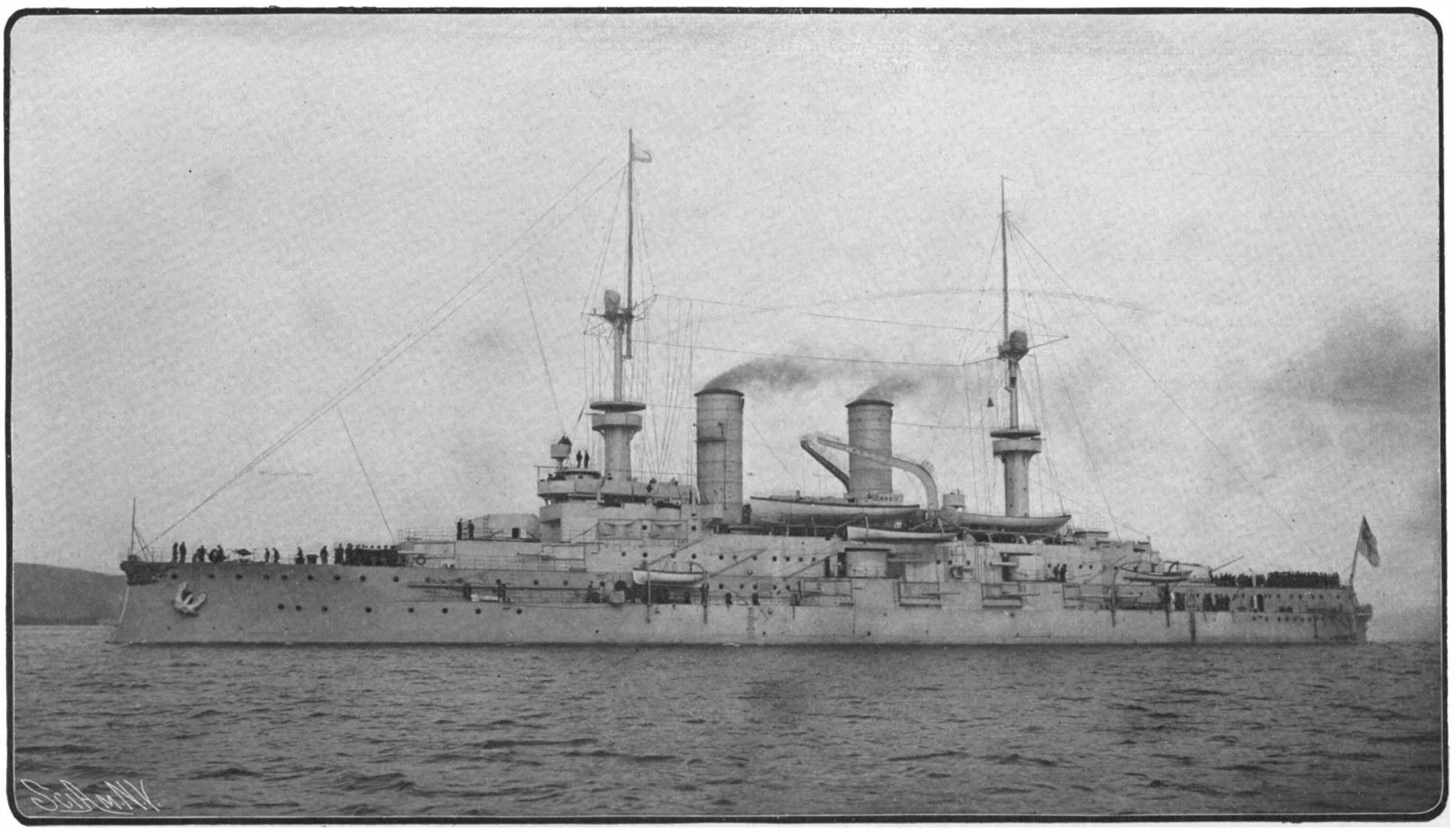
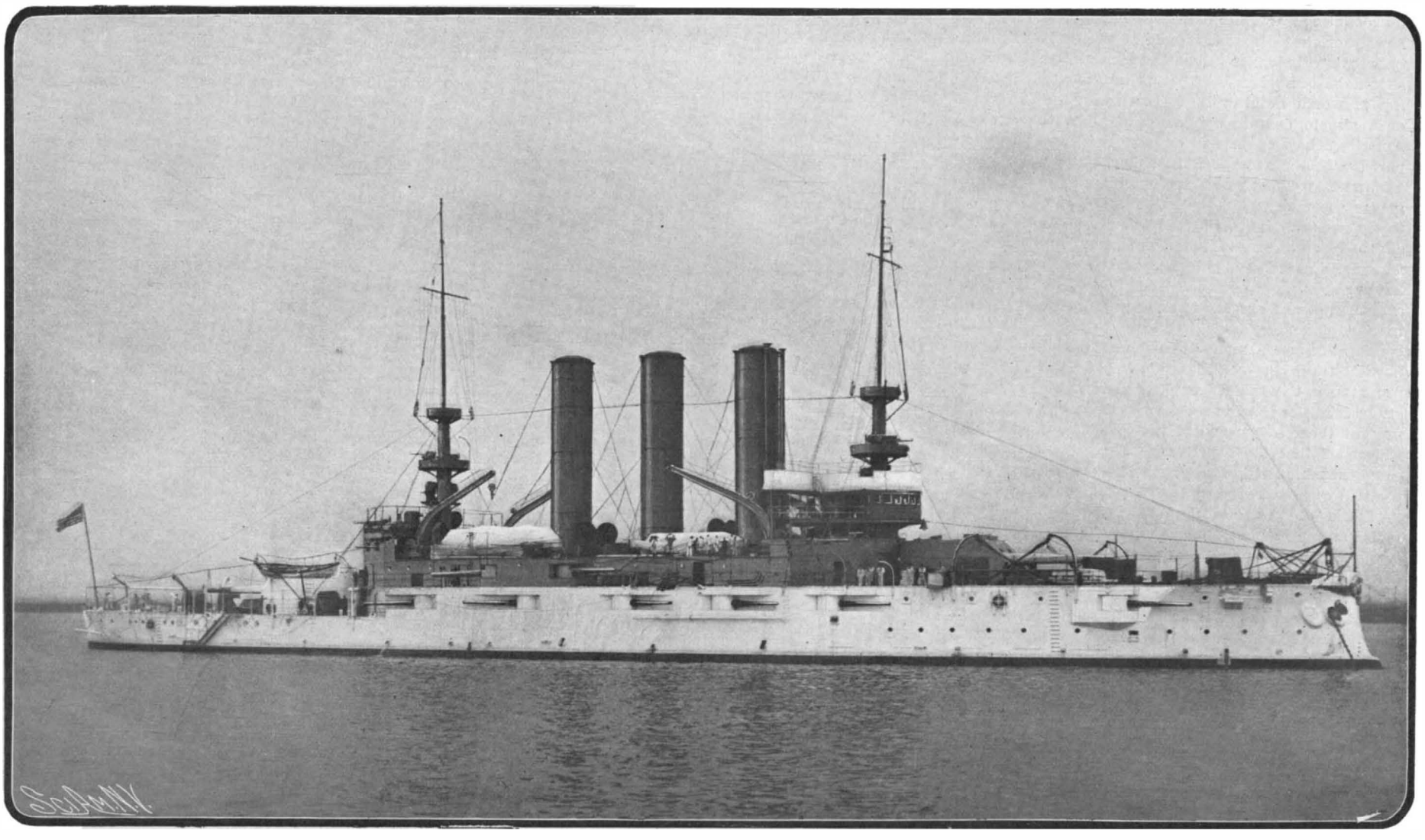


Displacement, 12,000 tons. **Speed,** 18 knots. **Maximum coal supply,** 1,000 tons. **Armament:** Four 9.4-inch, eighteen 6-inch, twelve 3.4-inch, twelve 1½-inch, eight machine guns. **Armor:** Belt, 9 inches; deck, 3 inches; gun positions, 10 inches. **Torpedo tubes,** 5 submerged, 1 above water. **Complement,** 650.

GERMAN BATTLESHIP "WETTIN."



Displacement, 12,300 tons. **Speed,** 18 knots. **Maximum coal supply,** 2,000 tons. **Armament:** Four 12-inch, sixteen 6-inch, six 3-inch, eight 6-pounders, six 1-pounders, two Colts, four machine guns. **Armor:** Belt, 12 inches; deck, 3 inches; gun positions, 8 to 12 inches. **Torpedo tubes,** 2 submerged. **Complement,** 551.

UNITED STATES BATTLESHIP "MAINE."—[See page 448.]