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PROCEEDINGS

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CONTENTS.

FACE HARDENED ARMOR. By Lieutenant A. A. Ackerman, U. S. N. Discussion,	1
THE U. S. COMMISSION OF FISH AND FISHERIES AND ITS RELATIONS WITH THE UNITED STATES NAVY. By Commander Z. L. Tanner, U. S. N.,	107
THE HOWELL TORPEDO. An Elementary Description. By Lieutenant Albert Gleaves, U. S. N.,	125
THE SOLAROMETER; A MODERN NAVIGATING INSTRUMENT. By Lieutenant W. H. Beehler, U. S. N. Discussion,	131
ELASTIC STRENGTH OF GUNS. By Lieutenant J. H. Glennon, U. S. N.,	175
PROFESSIONAL NOTES,	187
Leak Arresters for Ships.—Experiments on Wind Pressure.—A Reducible Life Buoy and the Galibert Respiratory Apparatus.	
BOOK NOTICE,	193
BIBLIOGRAPHIC NOTES,	195
THE CAPTURE OF WEI-HAI-WEI,	209
OFFICERS OF THE INSTITUTE,	211
ANNUAL REPORT OF SECRETARY AND TREASURER OF THE U. S. NAVAL INSTITUTE,	212
ADVERTISEMENTS.	



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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

FACE HARDENED ARMOR.

By LIEUT. A. A. ACKERMAN, U. S. Navy.

PREFACE.

The writer has long been impressed with the fact that the mode of resistance commonly ascribed to face hardened armor is incorrect. It seems that many have applied to it the theory upon which the development of compound armor was based. That is, the hard face was intended to smash the projectile without allowing penetration; the body and back was to assist the face under impact, and to hold it together even after it had cracked and failed.

Modern improved projectiles are seldom crushed from the point. The point may be fused and abraded or chipped off in breaking up the hard face, but actual disintegration of the projectile only occurs when the resistance that the plate is able to bring on the area of the shell in contact with it is sufficiently great to suddenly check the shell and cause it to break up over its weakest lines through its own inertia. Failure at the point may, however, arise even with low velocities, when the resistance of the plate is less local, provided the energy of the shot is incapable of effecting penetration, or in the case of inferior projectiles.

The usual action of the hard face, however, is that through its inability to bend or flow, it prevents the displacement of the more plastic metal beneath it towards the front, and thus brings the resistance of the whole thickness of the plate to bear before the projectile can advance.

The important retarding influence of the fragments of the hard face carried in by the projectile, is seen in the easier perforation obtained by projectiles whose ogivals are protected by soft steel caps. The cap appears to act as a lubricant or sleeve, covering the asperities of the hardened metal. It is necessary for the cap to be driven into the plate to derive any advantage from it. Doubtless, when thus confined this soft metal transmits pressure as rigidly as the projectile itself, but being capable of flowing, the steel slips through it comparatively unharmed. It is believed that a thicker hardened surface, undulated to prevent or limit flaking, will cause the projectile to carry in sufficient of the hardened face to render the cap incapable of performing the work required of it without increasing its size to a prohibitory extent.

The writer has much for which to thank the officers with whom he has been associated in the Bureau of Ordnance in the way of information. Mr. Millard Hunsiker, now in charge of the manufacture of armor at the Carnegie Steel Company's works, at Homestead, has also kindly placed at his disposal valuable information. He also owes considerable to the Inspectors of Ordnance and officials at the works of the armor makers. These gentlemen are in no way responsible, however, for the conclusions reached. It has been the intention of the writer throughout to avoid discussing those technical details which have been developed by and are the property of the manufacturer rather than the patentee, and by means of which alone the process of face hardening can be made a commercial success.

SECTION I.

HISTORY AND MANUFACTURE.

Face hardened armor is the direct outcome of efforts to avoid the failures resulting from attempts to temper homogeneous steel plates of sufficiently high carbon to give a very hard face. It is theoretically the perfect armor plate, and doubtless would have been developed long ago had that theory only been enunciated; for the various steps followed in its manufacture, except in certain details, have long been known to the metallurgical world.

Lieutenant Jacques makes the following statement in a recent discussion of the armor problem: "We will not enter here into a discussion of the merits of those who have succeeded in getting their names attached to the various patented methods of surface

hardening, but hope that those who deserve it will get the pecuniary benefit. Ellis treated the first thick plate many years ago; Harvey revived this method, and with the assistance of the Navy Department secured patents which received attention from abroad because of the prominence our Navy Department gave them."

The writer does not believe that Mr. Jacques intends to imply that the Navy Department has the power to obtain or assist to obtain an illegal patent. The assumption that Mr. Harvey revived the Ellis patent is not correct. The old cementation process was carried on usually in cast iron or fire-clay pots at a much lower temperature than that now employed. Had Mr. Harvey proposed merely to cement or convert steel at a temperature above that of molten cast iron, a temperature which would soon have destroyed the old cementation pots, there would still have been considerable novelty in the claim. But Mr. Harvey proposed to do something more by using this high temperature; he proposed to improve the steel, to impart to ingots or other objects of low steel, such as Bessemer steel, the qualities of refined crucible steel! That he succeeded in this, and that his process is in this respect one of a number somewhat akin to it by which inferior steel is improved, must be known to every steel maker. Whether this particular process is essential to the cementation of such high grade material as that of which armor is manufactured, is a different question. It is certain, however, that the Harvey patents cover the process when carried on at that high temperature.

There is an error of minor importance in the article of Lieutenant Jacques above mentioned. The title of Figure "F," Bethlehem 17-in. N-Steel Carbonized, Indiana's Barbettes," is incorrect. Later, in describing Figure "Y," the attack of the same plate by Johnson capped shot, he again speaks of it as carbonized. This was not the case, and its perforation should not be charged against face hardened armor; had the Indiana's 17-inch Barbette plate been face hardened, the premium velocity shot would have smashed on it, as it did on the "Massachusetts" Barbette, instead of perforating it with ease.

The writer has the greatest respect for the energy and ability of Mr. Ellis, but if credit is to be given for the cementation of armor, he must share the honor with others.