INTRODUCTION

The Ti-6Al-4V alloy is recognized as the most important alloy in the titanium industry. Because it is perhaps the most versatile grade of titanium ever developed it has grown in application until it has earned the nickname "workhorse" of titanium alloys. The Naval Sea Systems Command (NAVSEA) recognized the potential of Ti-6Al-4V and has sponsored work at the David W. Taylor Naval Ship R & D Center (DTNSRDC), the Naval Research Laboratory (NRL), and industry to investigate it for possible marine uses. A material for marine applications should possess good toughness and insensitivity to the marine environment. Properties such as seawater stress corrosion resistance and seawater fatigue resistance are of major concern. The NAVSEA investigations have been aimed at not only investigating these properties but where possible developing them to their maximum potential. Areas of interest have included plate development, weldment development, forming effects, and castings. This paper is a brief summary of some of the more significant NAVSEA investigations performed on the Ti-6Al-4V alloy in its development for marine applications.

Evaluation Factors

Important properties to be considered in evaluating a structural metal for marine applications include strength, toughness, seawater stress corrosion resistance (SCC), and fatigue characteristics. Strength properties determined in the NAVSEA investigations include 0.2% offset tensile yield strength (TYS), ultimate tensile
strength (UTS), 0.2% offset compressive yield strength (CYS), percent elongation (% El), and percent reduction in area (%RA). All strength values in this paper are expressed in units of thousand pounds per square inch (ksi). Toughness property tests include the Dynamic Tear Test (DT) [1] and the Charpy V-notch impact test (CV). Seawater stress corrosion tests were conducted by the NRL cantilever beam stress corrosion test [2] in which the threshold $K_{I}$SCC stress intensity factor is determined as ksi $\sqrt{in}$. In most cases a threshold stress intensity factor was also determined for specimens tested in air in the same manner as those tested in seawater. This value is designated $K_{I}$air. Threshold values were determined for test periods ranging from one to 100 hours. High cycle fatigue tests were conducted using rotating cantilever beam specimens and R. R. Moore fatigue specimens [3]. Fatigue strength was determined for a life of $10^8$ cycles.

**Ti-6Al-4V Plate**

The major portion of the NAVSEA effort on the Ti-6Al-4V alloy has been spent in investigating the alloy in plate form, principally in one-inch thickness. As toughness and seawater stress corrosion resistance are of prime concern for most plate applications, investigations have been concentrated on achieving the maximum in these properties. In most of the investigations properties were determined both longitudinal and transverse to the principal rolling direction. In the interest of brevity, however, properties reported in this paper are transverse with respect to the principal rolling direction. This direction has been found to be the "weak" direction for toughness properties. Tensile and compressive strength specimens were taken parallel to the principal rolling direction. DT, CV, and SCC specimens were made such that the notch orientation was perpendicular to the rolled surface and the fracture is driven in the principal rolling direction.

**Effect of Oxygen Content.** An investigation was conducted to determine the effect of oxygen content on the properties of 1-inch plate produced from 100 lb ingots. The aim for oxygen contents were 0.06, 0.08, 0.10, and 0.12 weight percent (wt %) with other elements held constant within practical limits. Plates were specified to be produced according to current mill practice. This consisted of beta forging each ingot, starting at 2200 F, to a 4-inch slab. The forged slab was alpha + beta cross-rolled to a 1-inch thickness from a starting temperature of 1850 F. Results of this investigation are summarized in Table I.