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Implants for surgery — Metallic materials — Classification of microstructures for alpha+beta titanium alloy bars

Implants chirurgicaux — Matériaux métalliques — Classification des microstructures des barres en alliages de titane alpha+bêta

Reference number
ISO 20160:2006(E)

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 20160 was prepared by Technical Committee ISO/TC 150, *Implants for surgery*, Subcommittee SC 1, *Materials*.

Introduction

Some ISO Standards on alpha+beta titanium implant materials refer to a set of microstructural configurations provided in the ETTC2 brochure which was published first in 1979 by the Technical Committee of European Titanium Producers [1]. A reprint of ETTC2 containing some additions was made available in 1995.

In contrast to homogeneous material structures for which standards are available to determine the grain size of the microstructures (ISO 643, ASTM E112), no standards exist for the classification of the more complex alpha+beta titanium microstructures, although the alpha+beta alloys are the most frequently used technical titanium materials.

This International Standard follows the repeated request to make available the relevant set of microstructures of alpha+beta titanium alloy bars from the ETTC 2 publication as a standard document for easy access.

The ISO Technical Committee ISO/TC 150/SC 1 *Materials*, expresses its gratitude to the publishers of the ETTC 2 brochure for granting the reproduction of selected micrographs for the purpose of this International Standard.

Implants for surgery — Metallic materials — Classification of microstructures for alpha+beta titanium alloy bars

IMPORTANT — For the correct identification of microstructures, it is necessary to use reference micrographs of suitable quality and precise dimensions as contained in this International Standard. Owing to the fact that electronic copies of these reference micrographs are subject to change when viewed on screen or printed, it is recommended that only the micrographs contained in printed copies of this International Standard purchased from ISO or ISO members and their distributors be used for purposes of comparison.

1 Scope

This International Standard provides a catalogue of metallographic photomicrographs for the designation of microstructures of alpha+beta titanium alloys in the form of bars that are intended for the manufacture of surgical implants. This International Standard is applicable to bars of diameter no greater than 100 mm or the equivalent.

This catalogue of microstructures is intended to serve as an aid in the communication on general types of microstructures of alpha+beta titanium alloy bars. The designation of the microstructures is based on morphological appearance. Actual microstructures can also appear as a combination of the type of micrographs shown.

This International Standard does not contain specific microstructural requirements. The catalogue includes photomicrographs of desirable and undesirable microstructures that can develop during the processing of alpha+beta titanium alloys. The selection of acceptable microstructures is subject to agreement under the consideration of implant application and relevant material standards.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ASTM E407-99, *Standard Practice for Microetching Metals and Alloys*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
alpha+beta titanium alloys
titanium alloys composed of alloying elements which propagate the stabilization of the titanium alpha/beta phase with hexagonal and body-centered crystal atomic structures, respectively

NOTE The constitution diagrams of these alloys present typically alpha+beta phase regions that are stable up to room temperature (see also 4.1).

3.2
alpha+beta (titanium) microstructures
metallographic microstructures of alpha+beta titanium alloys that contain predominantly the alpha/beta phase

NOTE Metastable phases can be included.

3.3
bar material
material processed in the longitudinal direction provided in form of (straight) bars with a specified cross-sectional shape

NOTE Bar material is distinct from wire, which is supplied in spools.

4 General considerations and applicability

4.1 General considerations

Pure titanium transforms from the hexagonal atomic structure (alpha phase) into the body-centred cubic structure (beta phase) at the temperature of 882 °C. Below this transition temperature the cubic beta phase is not stable. However, the addition of certain alloying elements stabilizes the beta phase at lower temperatures. By this means typical so-called alpha+beta titanium alloys have been developed where the alpha and beta phases are stable at room temperature. Through the addition of alloying elements the transition temperature, the so-called Beta-Transus, will be changed. With the presence of alpha+beta structure the mechanical properties of the titanium can be altered [2].

Depending on the material composition and the processing history, different microstructural configurations appear.

The catalogue of metallographic micrographs given in Annex A contains typical microstructural configurations as they occur in the metallurgical processing of alpha+beta titanium alloys, of which the titanium with 6 % aluminium and 4 % vanadium is considered representative.

4.2 Applicability

The micrographs given in Annex A are identified by the letter “A” followed by a number. This classification of micrographs is intended as a basis for the communication on typical morphological microstructural conditions viewed on transverse metallographic sections of bar material.

The choice of the desired and undesired microstructural configurations may depend on the application of the material, the applicable material standards, as well as agreements.

The micrographs in Annex A were originally published in ETTC 2 for Ti-6Al-4V bar material, but are also applicable to other alpha+beta alloys applied for surgical implants [3], [4].

5 Procedure

5.1 Magnification

The micrographs A 1 to A 24 in Annex A represent transverse sections of bar material at a magnification of × 200.

5.2 Identification

In order to identify the type of microstructure of a given alpha+beta titanium material by comparison with the micrographs in Annex A, transverse sections of the material shall be prepared metallographically and etched.

Etching techniques suitable for titanium alloys which give results similar to those shown on the micrographs in Annex A shall be applied. ASTM E 407-99 for microetching techniques shall be used for guidance. The etchant number 192 listed is commonly applied and recommended.

NOTE Within the concentration range of etchant number 192, a solution composed of 100 ml H_2O + 2 ml HF (40 % mass fraction) + 8 ml HNO_3 (ρ = 1,4) has been found suitable in routine practice.

The metallographic sections are examined at × 200 magnification using an optical microscope and bright field illumination. For the sake of comparison the most similar type of microstructure is selected from Annex A and its designation is reported (Type AX). Additional information may be added (such as “Type A3 but with apparently smaller alpha grain size”).

In case it is desired to determine the grain size of the matrix in a given microstructure, ISO 643 should apply [5]. In case a given microstructure is in between two types of micrographs both may be identified (e.g. “Type A 1/A 2”). Where the type of microstructure varies over the cross-section of a material sample, the type of microstructural characteristic of the different areas of the cross-section may be identified.

Annex A
(normative)

Catalogue of metallographic micrographs of typical alpha+beta titanium microstructures of transverse sections of bar material of diameters no greater than 100 mm or its equivalent

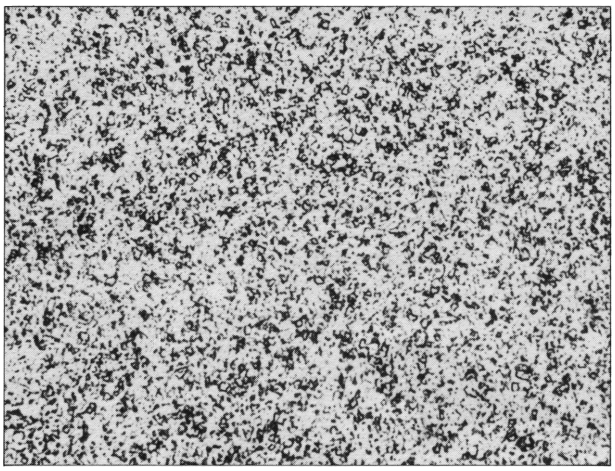
For identification of the microstructure of a given material by comparison with the following micrographs, the material shall be viewed at a microscopic magnification of × 200.

NOTE 1 Microstructures corresponding to the micrographs A 20 to A 24 are classified as unacceptable in ETTC 2 edition 1.

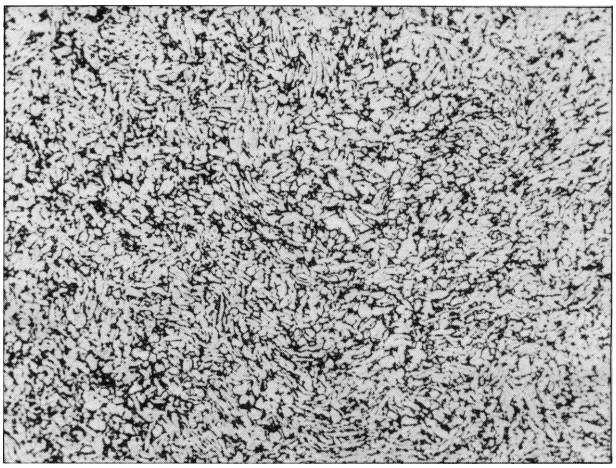
NOTE 2 The order and designation of micrographs in Annex A relate to the arrangement given in the second edition (1995) of the ETTC 2 publication. The first edition contains the same micrographs, however the order of the micrographs with the designations A 10 to A 17 differs. In order to avoid confusion, the correlation of the designation of the micrographs between edition 1 and 2 of ETTC 2 are given in Table A.1.

Table A.1 — Correlation between designations of micrographs

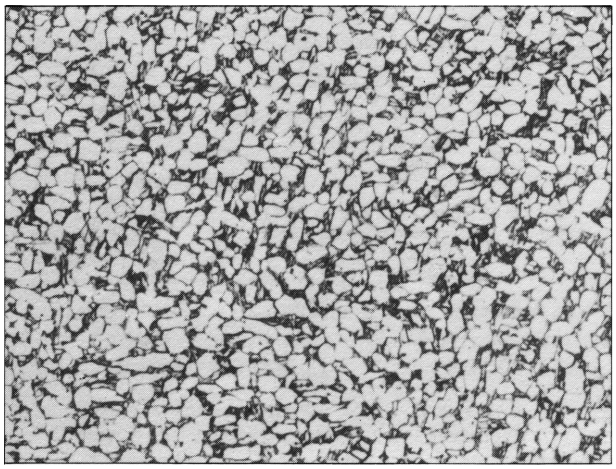
ETTC 2 edition 1	ETTC 2 edition 2
A 10	A 17
A 11	A 10
A 12	A 11
A 13	A 12
A 14	A 13
A 15	A 14
A 16	A 15
A 17	A 16



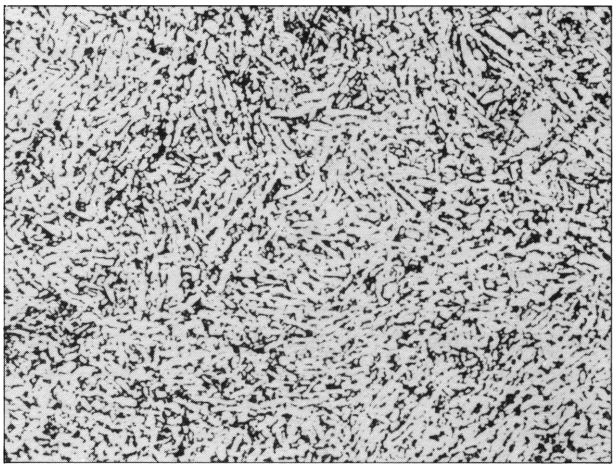
A 1 × 200



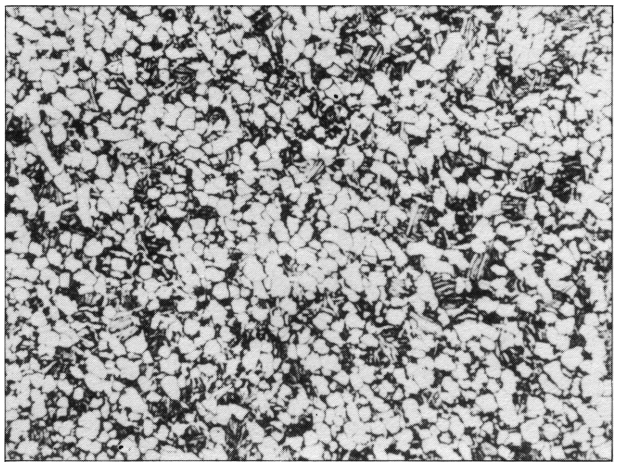
A 2 × 200



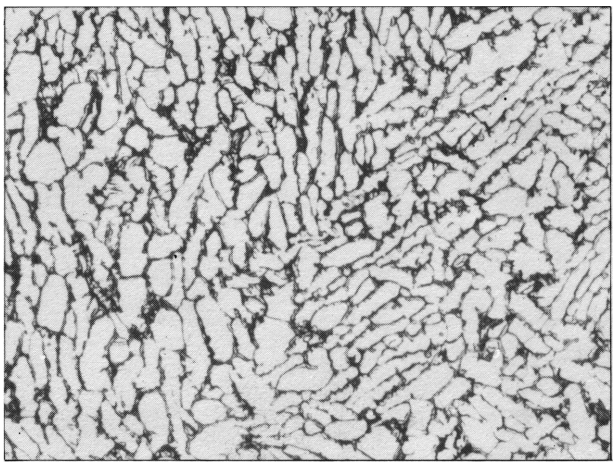
A 3 × 200



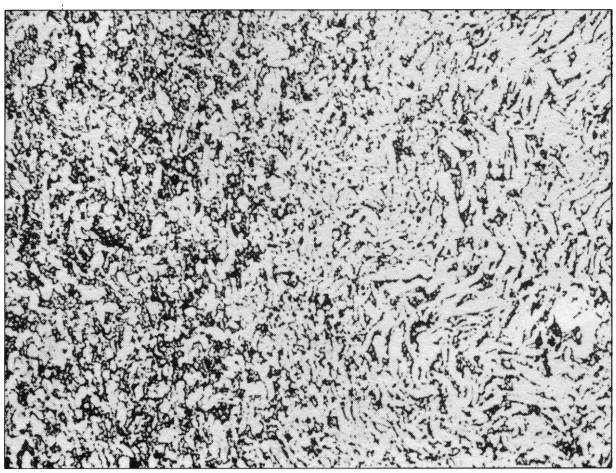
A 4 × 200



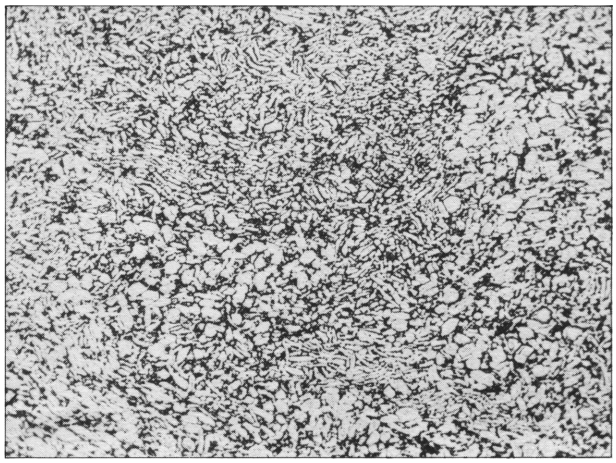
A 5 × 200



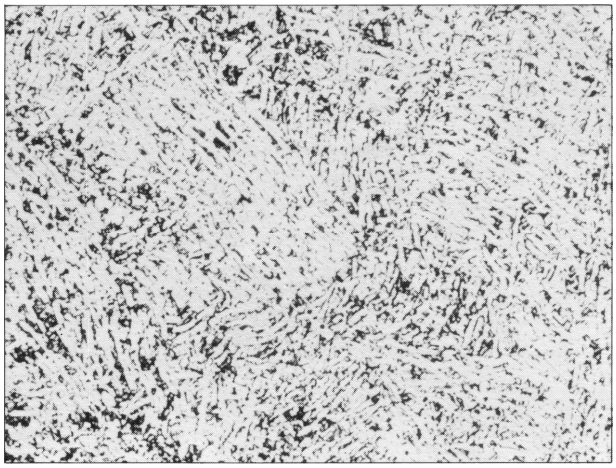
A 6 × 200



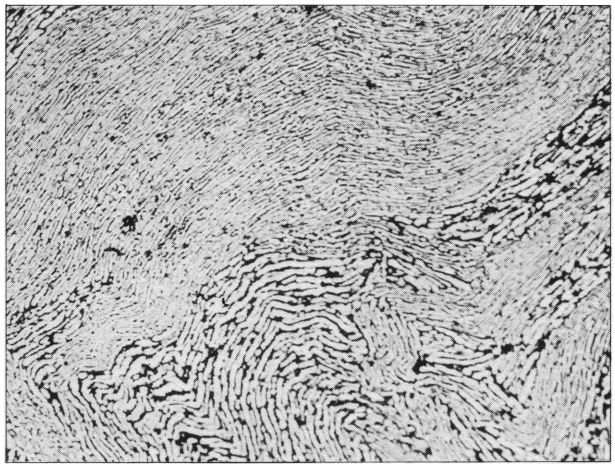
A 7 × 200



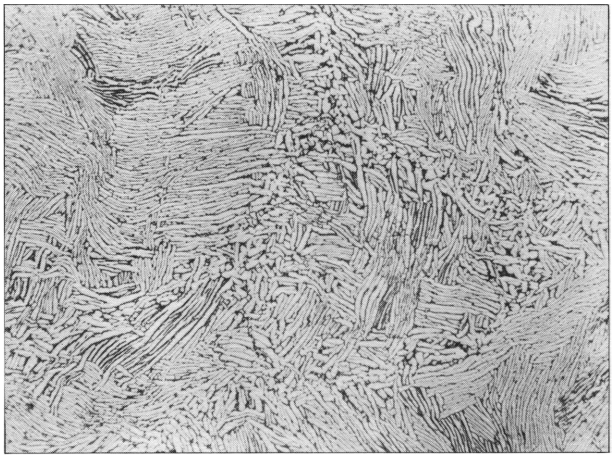
A 8 × 200



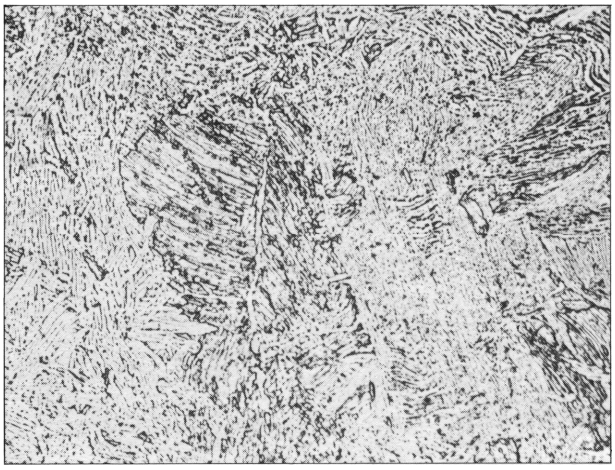
A 9 × 200



A 10 × 200

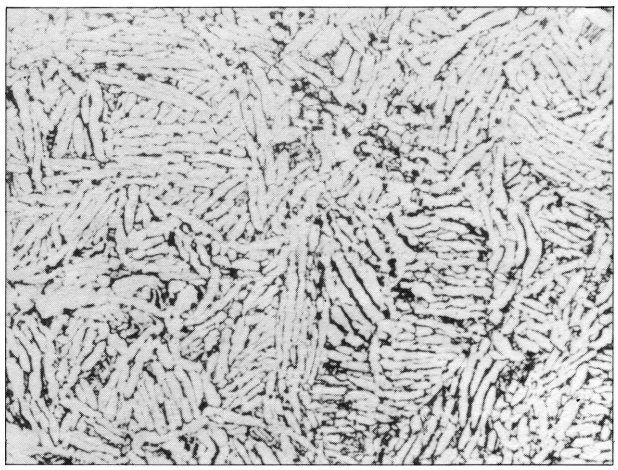


A 11 × 200

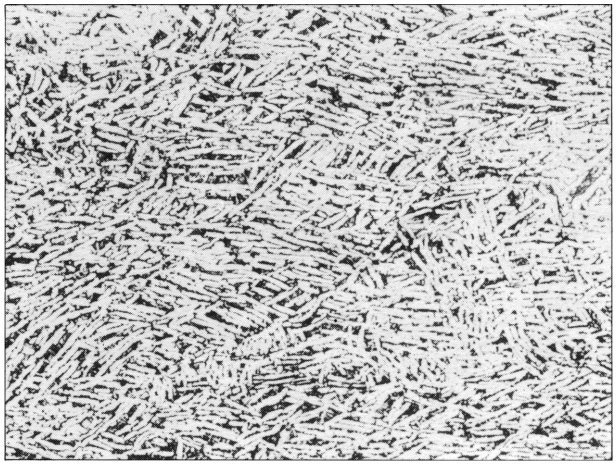


A 12 × 200

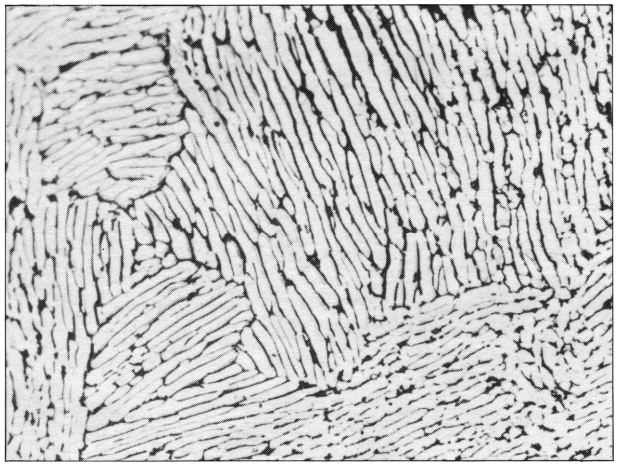
A 13 × 200



A 14 × 200

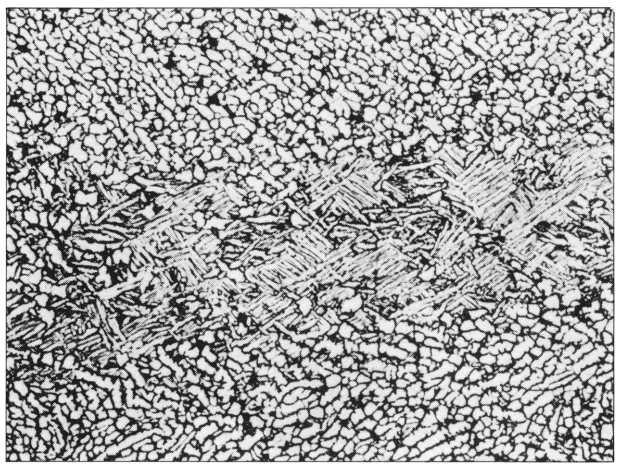


A 15 × 200

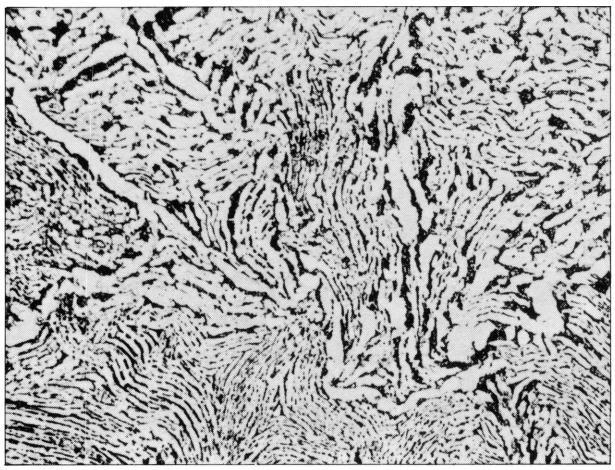


A 16 × 200

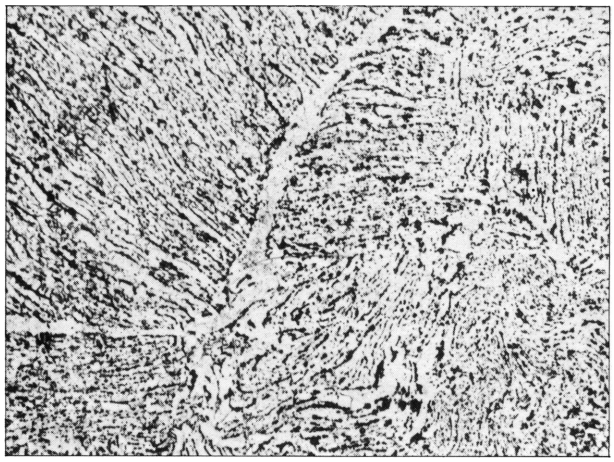
A 17 × 200



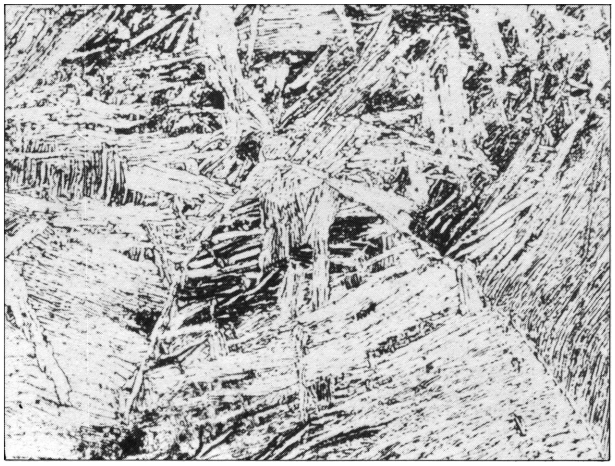
A 18 × 200



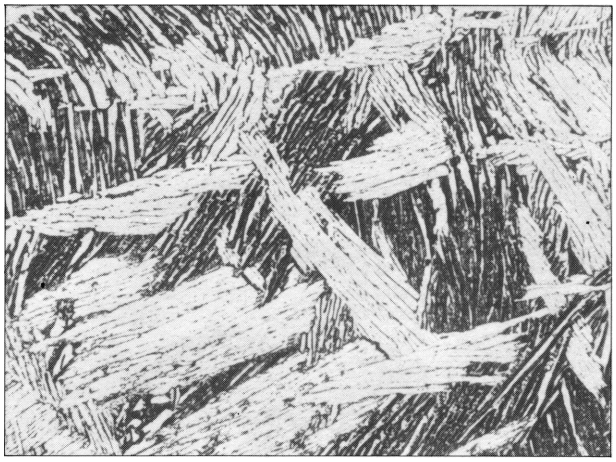
A 19 × 200



A 20 × 200

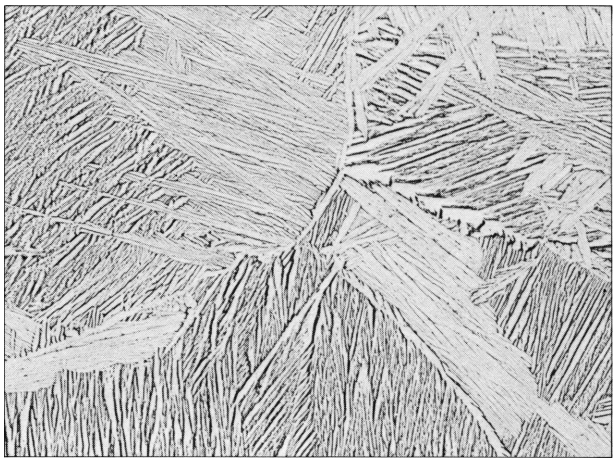


A 21 × 200



A 22 × 200

A 23 × 200



A 24 × 200

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[1] Publication ETTC 2, *Microstructural standards for alpha+beta titanium alloy bars*, prepared by the Technical Committee of European Titanium Producers, 1979; Edition 2, 1995, TIG (Titanium Information Group) Unit 34, Middlemore Trading Estate, Smethwick, West Midlands B66 2EE, UK or TIMET UK, PO Box 704 Witton, Birmingham B6 7UR, UK

[2] *Titanium in Medicine*, (editors D.M.Brunette, P.Tangvall, M.Textor, P.Thompson), Chapter 3, FREESE, H.L., VOLAS, M.G., WOOD, J.R.; Chapter 23, PERREN, S.M., POHLER, O.E.M., SCHNEIDER, E. 2001, Springer Berlin Heidelberg New York, ISBN: 3-540-66936-1

[3] ISO 5832-3, *Implants for surgery — Metallic materials — Part 3: Wrought titanium 6-aluminium 4-vanadium alloy*

[4] ISO 5832-11, *Implants for surgery — Metallic materials — Part 11: Wrought titanium 6-aluminium 7-niobium alloy*

[5] ISO 643, *Steels — Micrographic determination of the apparent grain size*

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