

THE SPRING RESEARCH ASSOCIATION

THE PRODUCTION OF SPRING FATIGUE DATA
WITH STATISTICAL LEVELS OF CONFIDENCE

Part 7 of 7 parts

SPRING DESIGN DATA

by

G. C. Bird, B.Sc.

Report No. 229

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1. INTRODUCTION

This part of the report contains a summary of the recommended uses and manufacturing processes for each type of material tested. In addition, design data on each type of material in both the unpeened and shot peened conditions is given in the form of fatigue diagrams at the end of this part.

2. HEAT TREATMENT

Data given in this report is for springs which have undergone a low temperature heat treatment after coiling to remove the stresses induced in coiling the spring and to raise the elastic properties of the wire (as well as for those springs to BS 1429, En 47 which are coiled from annealed material and oil-hardened and tempered to 500/550 HV after coiling). Details of the recommended low temperature heat treatments are given below:

BS 1408 C and D	350°C for 30 minutes
BS 2803	350°C - 400°C for 30 minutes
BS 2056; En 58A, En 58J	400°C - 450°C for 2 hours
BS 1429; En 47	350°C - 400°C for 30 minutes unless hardened and tempered after coiling

3. SHOT PEENING

Peened springs, covered by these recommendations are shot peened to an Almen arc rise of 0.45/0.55mm (0.018/0.022in) using cast steel shot in the size range of 0.75mm - 1.0mm (S330 shot). After shot peening springs must be given another low temperature heat treatment of 220°C for at least half an hour.

4. PRESTRESSING

These recommendations are for springs which, following the heat treatment, are prestressed to solid until the free length becomes stable. For fatigue applications it is important that the springs are designed to allow the correct amount of prestressing. The values below give the recommended working and solid stresses for springs which have been low temperature heat treated and prestressed. The stresses are expressed as a percentage of the minimum specified tensile strength of the wire (or N/mm² for En 47).

Material	Solid Stress	Maximum Working Stress
Patented cold drawn spring steel wire - BS 1408	70%	62%
Oil-hardened and tempered steel wire - BS 2803	70%	62%
Cold drawn stainless steel wire to BS 2056 En 58A	57%	50%
Chrome-vanadium alloy steel, hardened and tempered after coiling to BS 1429, En 47 (500/550 HV)	1060 N/mm ²	900 N/mm ²

For the materials other than En 47, these values have been shown graphically in terms of corrected torsional stress in Figs 1 - 5.

5. FATIGUE DIAGRAMS

The fatigue diagrams shown in Figs 6 to 27 represent the fatigue properties of the materials tested in both the unpeened and shot peened conditions to a level of confidence which is equal to or in excess of 99.9%. The solid horizontal line across the top of the diagram represents the solid stress of the spring and the dotted horizontal line represents the maximum working stress to which the spring should be subjected.

The values of solid stress on the fatigue diagrams are the recommended values derived from the data given in Section 4 (Page 2), for the 4mm wire diameter used in the tests.

The solid stress of the actual springs used in the tests did not always have these values, but the Goodman diagrams were derived in the manner described in SRA Research Report No. 219.

The solid stress of the spring should be designed to be approximately 15% greater than the maximum working stress.

The graphs of fatigue characteristics give values for maximum working stress depending upon the initial stress and the number of reversals. Values are given at lives of 10^5 cycles, 10^6 cycles and 10^7 cycles for most materials. Where necessary, intermediate values for other life conditions can be estimated.

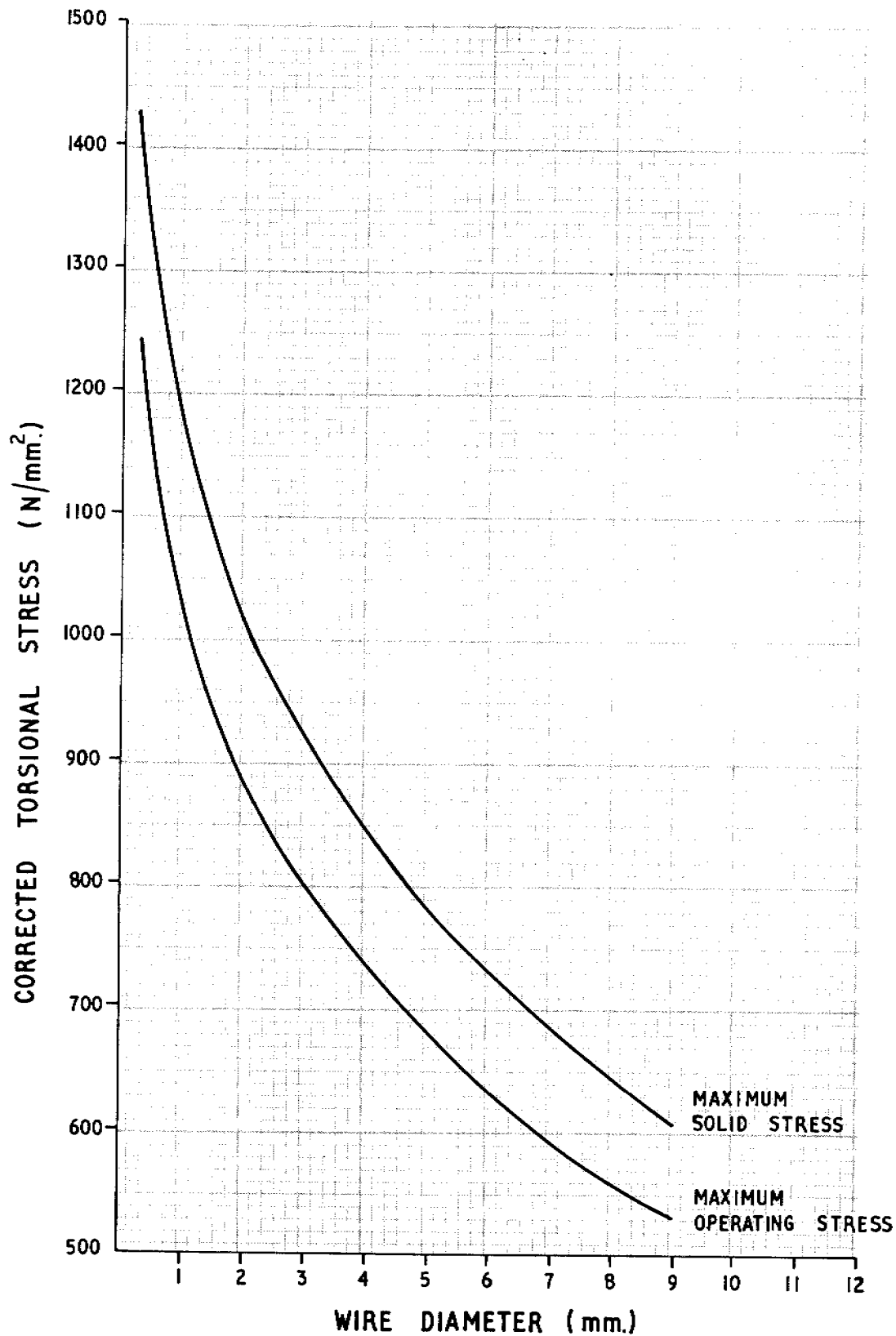


FIG. 1. MAXIMUM PERMISSIBLE STATIC OPERATING AND SOLID STRESSES FOR HARD DRAWN PATENTED WIRE B.S. 1408B, C AND D RANGE I, LOW TEMPERATURE HEAT TREATED AND PRESTRESSED.

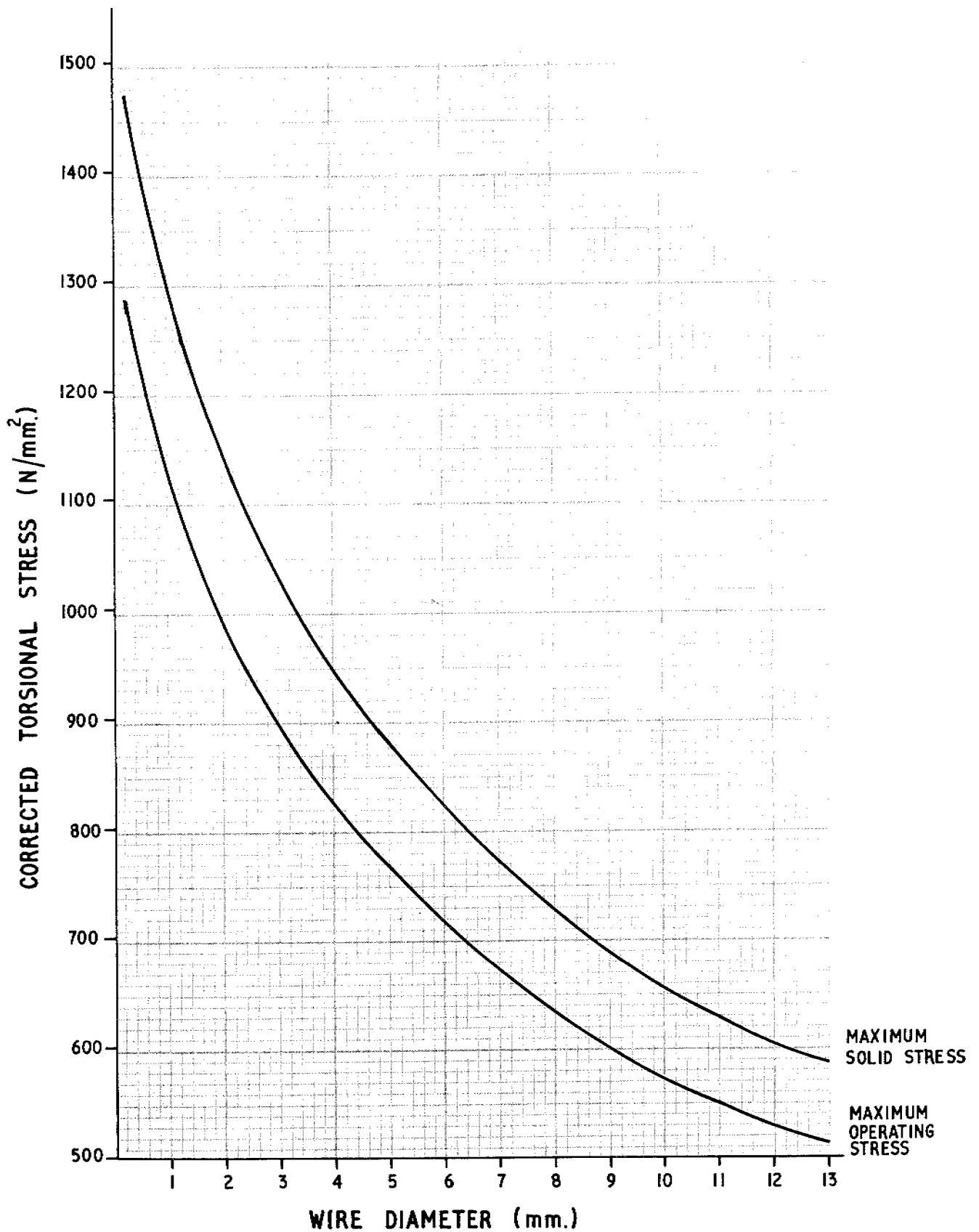


FIG. 2. MAXIMUM PERMISSIBLE STATIC OPERATING AND SOLID STRESSES FOR HARD DRAWN PATENTED WIRE B.S. 1408 B, C AND D RANGE 2, LOW TEMPERATURE HEAT TREATED AND PRESTRESSED.

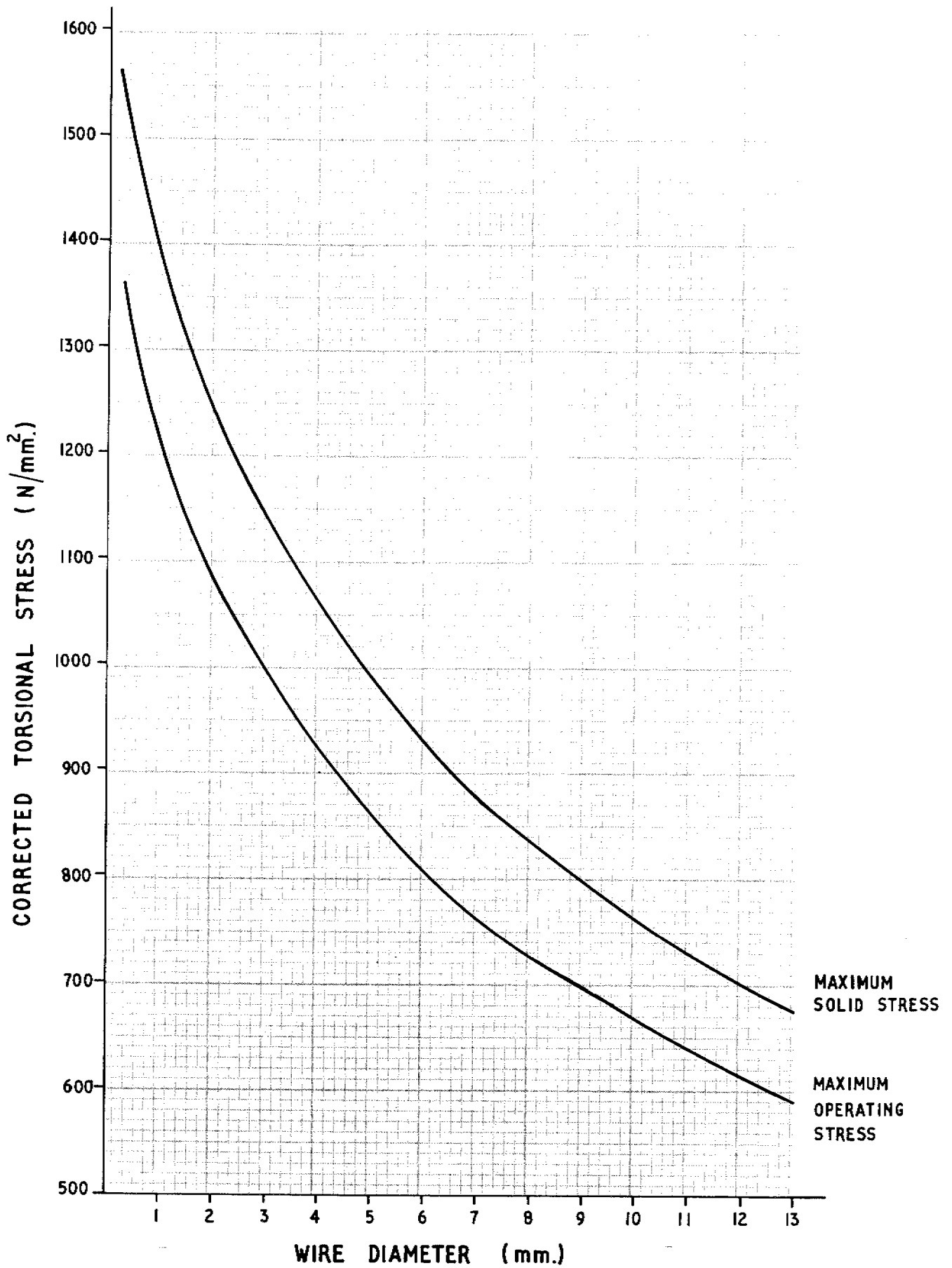


FIG. 3. MAXIMUM PERMISSIBLE STATIC OPERATING AND SOLID STRESSES FOR HARD DRAWN PATENTED WIRE B.S.1408 B, C AND D RANGE 3, LOW TEMPERATURE HEAT TREATED AND PRESTRESSED.

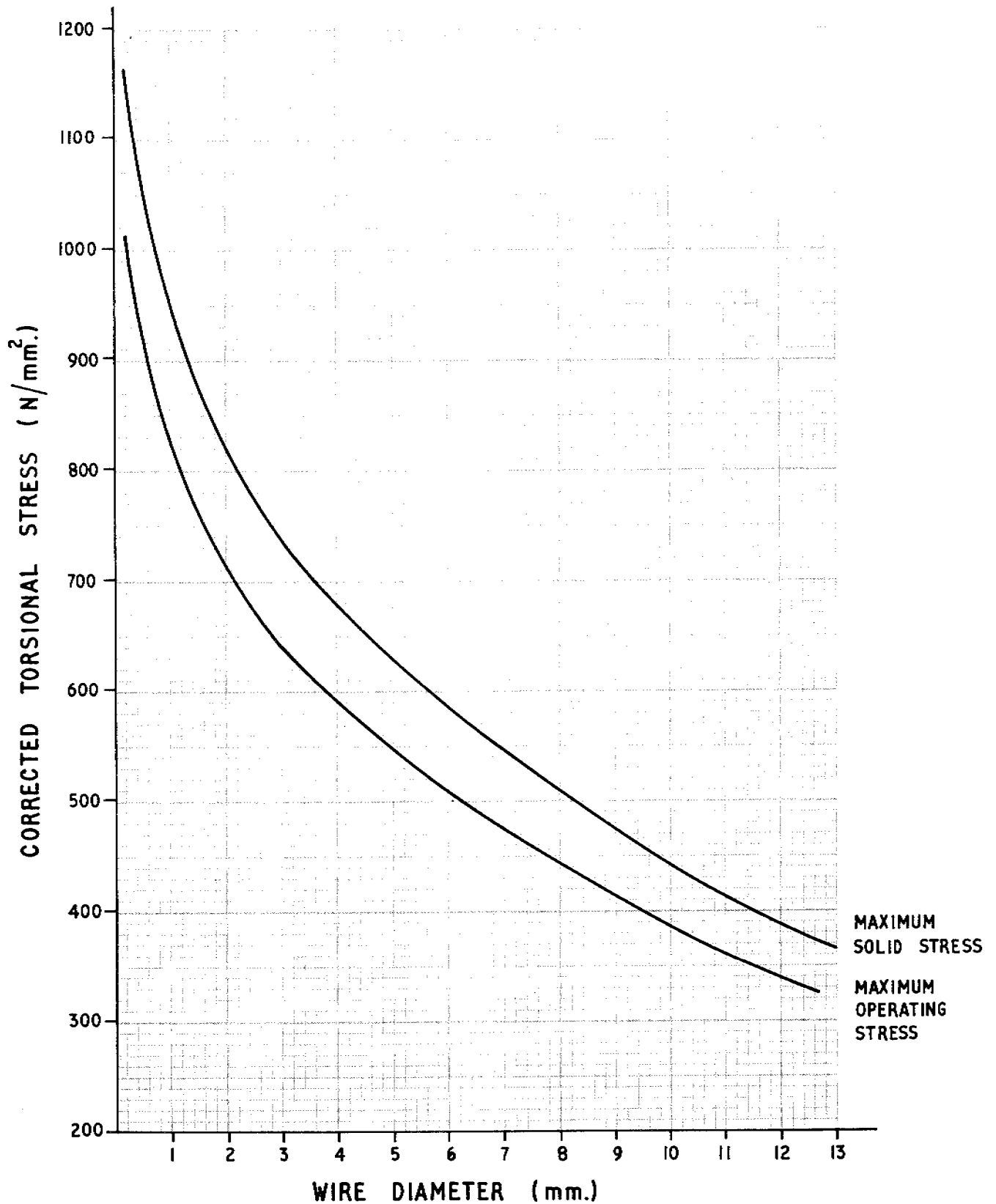


FIG. 4. MAXIMUM PERMISSIBLE STATIC OPERATING AND SOLID STRESSES FOR HARD DRAWN 18/8 STAINLESS STEEL WIRE B.S. 2056 (En 58A) LOW TEMPERATURE HEAT TREATED AND PRESTRESSED

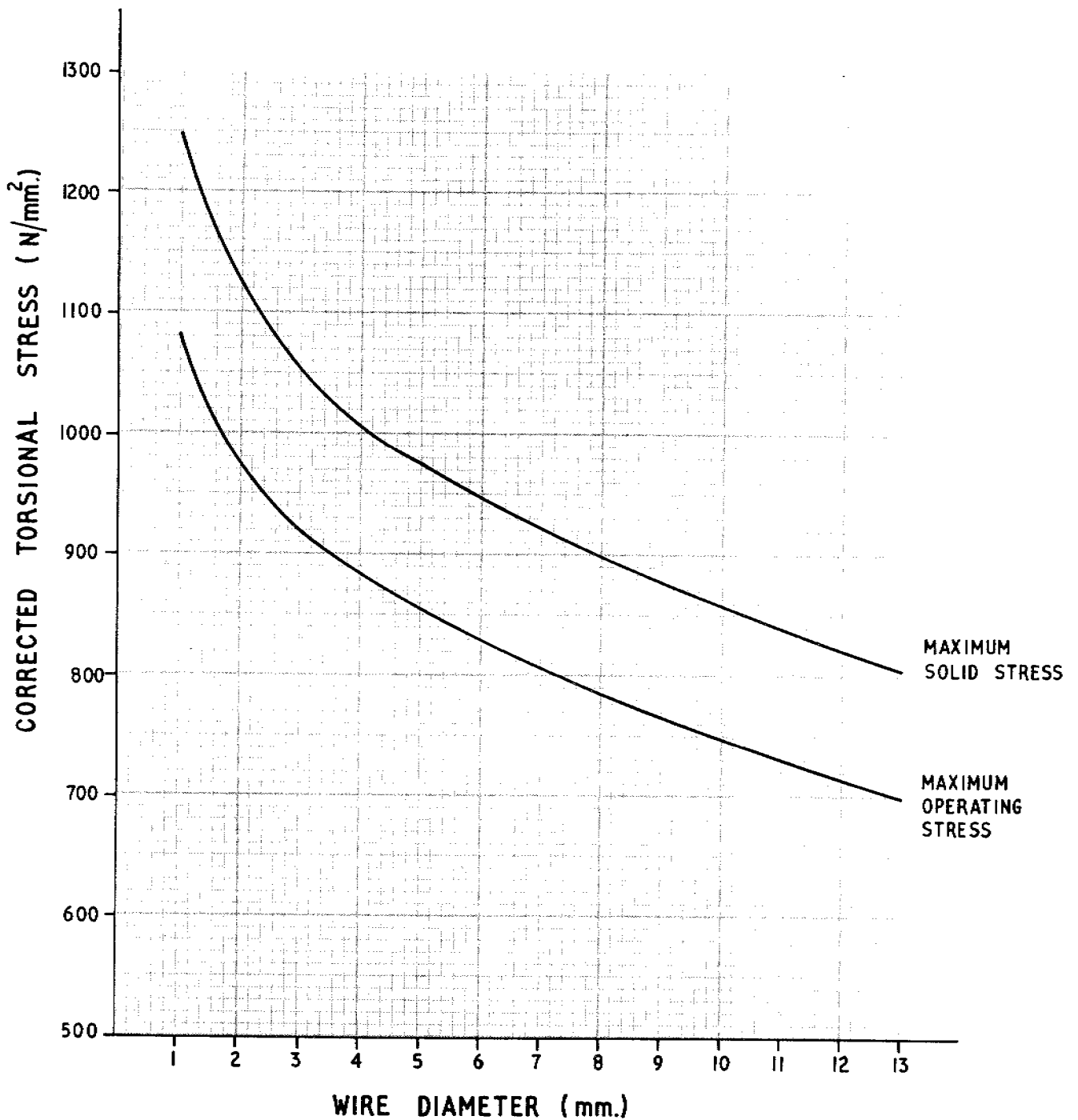


FIG. 5. MAXIMUM PERMISSIBLE STATIC OPERATING AND SOLID STRESSES FOR OIL HARDENED AND TEMPERED CARBON STEEL WIRE B.S. 2803 GRADES I, II AND III, LOW TEMPERATURE HEAT TREATED AND PRESTRESSED

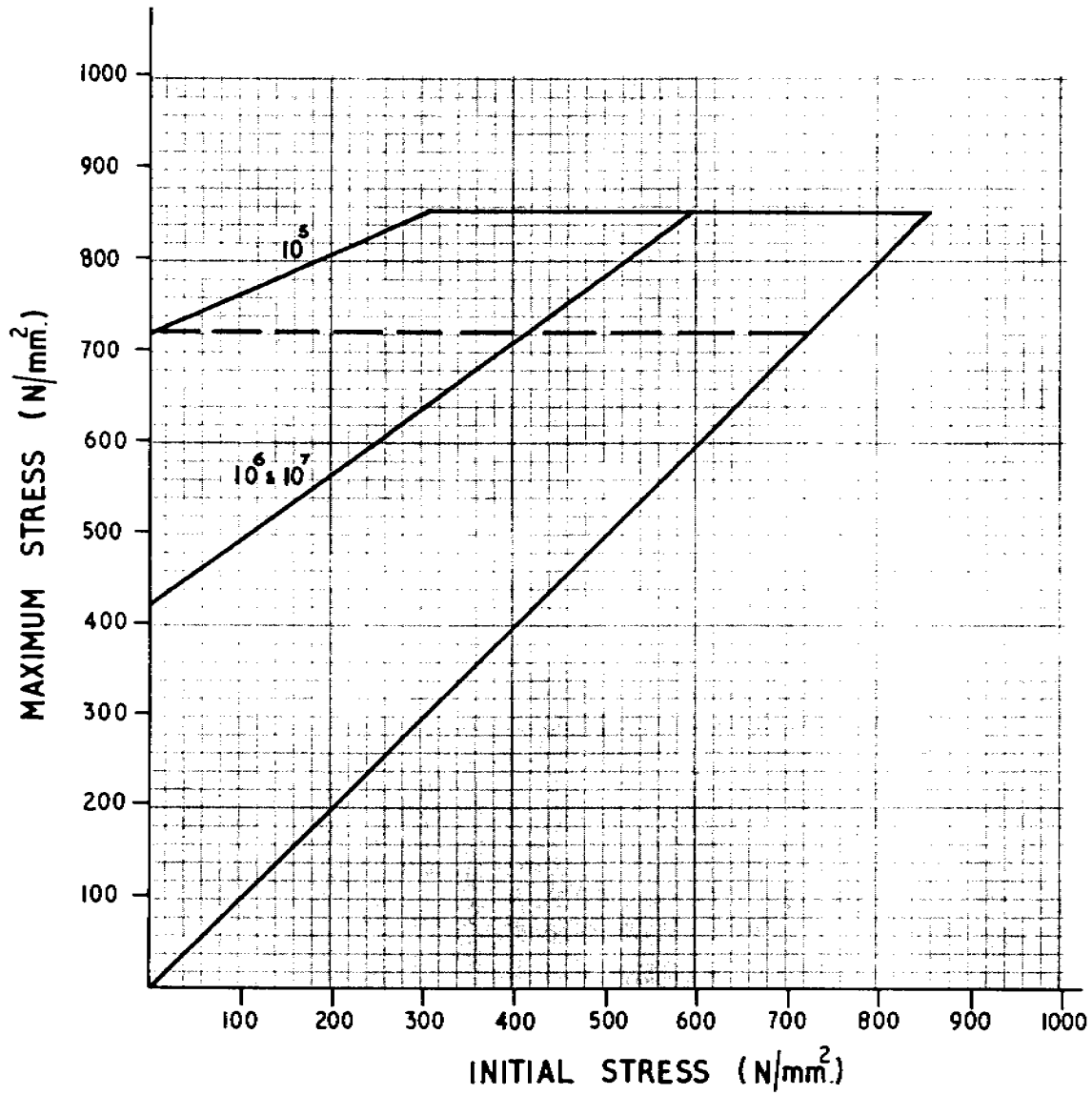


FIG. 6. FATIGUE DIAGRAM FOR PRESTRESSED,
UNPEENED HARD DRAWN PATENTED WIRE
TO B.S. 1408 C RANGE I

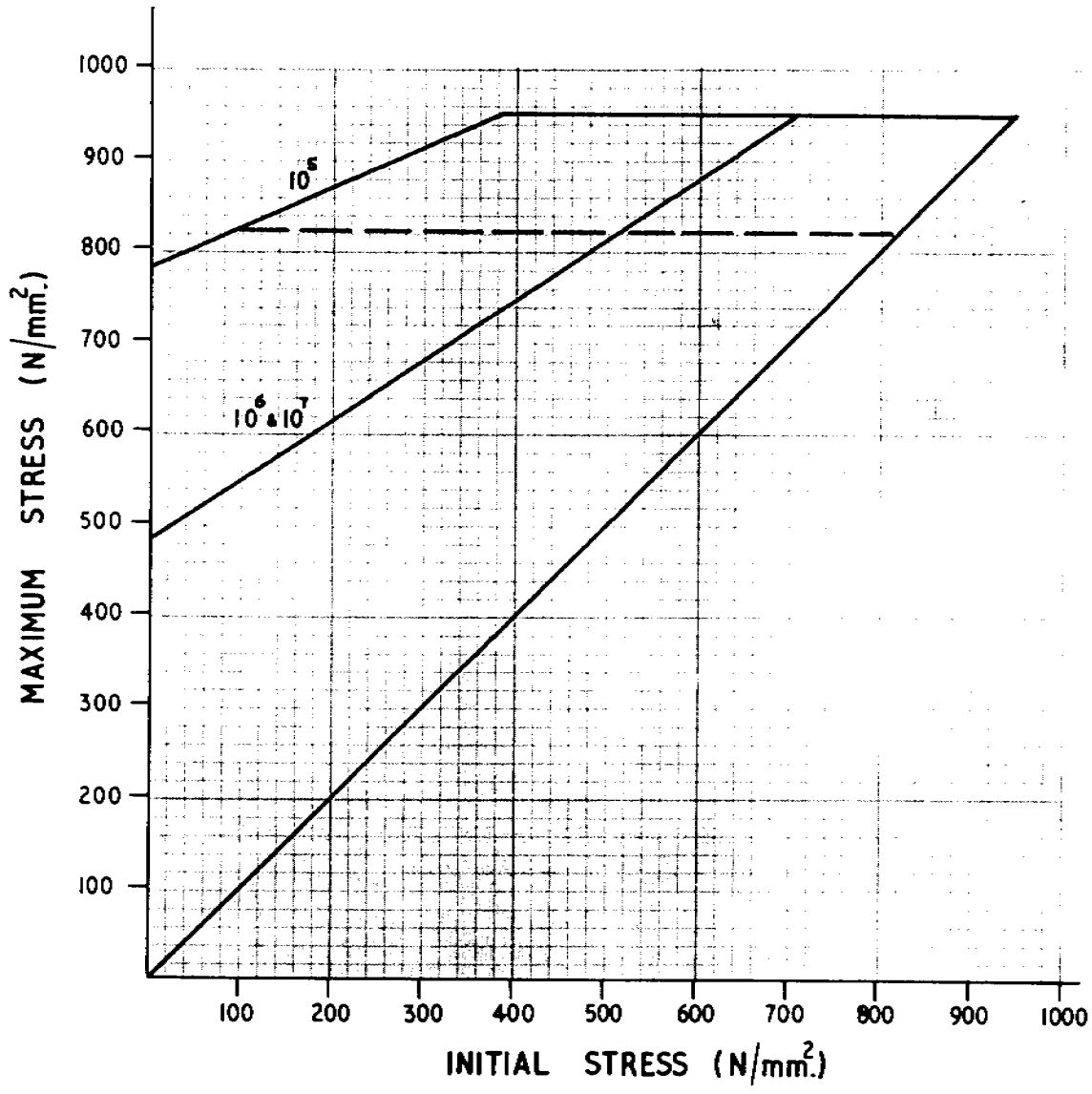


FIG. 7. FATIGUE DIAGRAM FOR PRESTRESSED,
UNPEENED HARD DRAWN PATENTED WIRE
TO B.S. 1408C RANGE 2

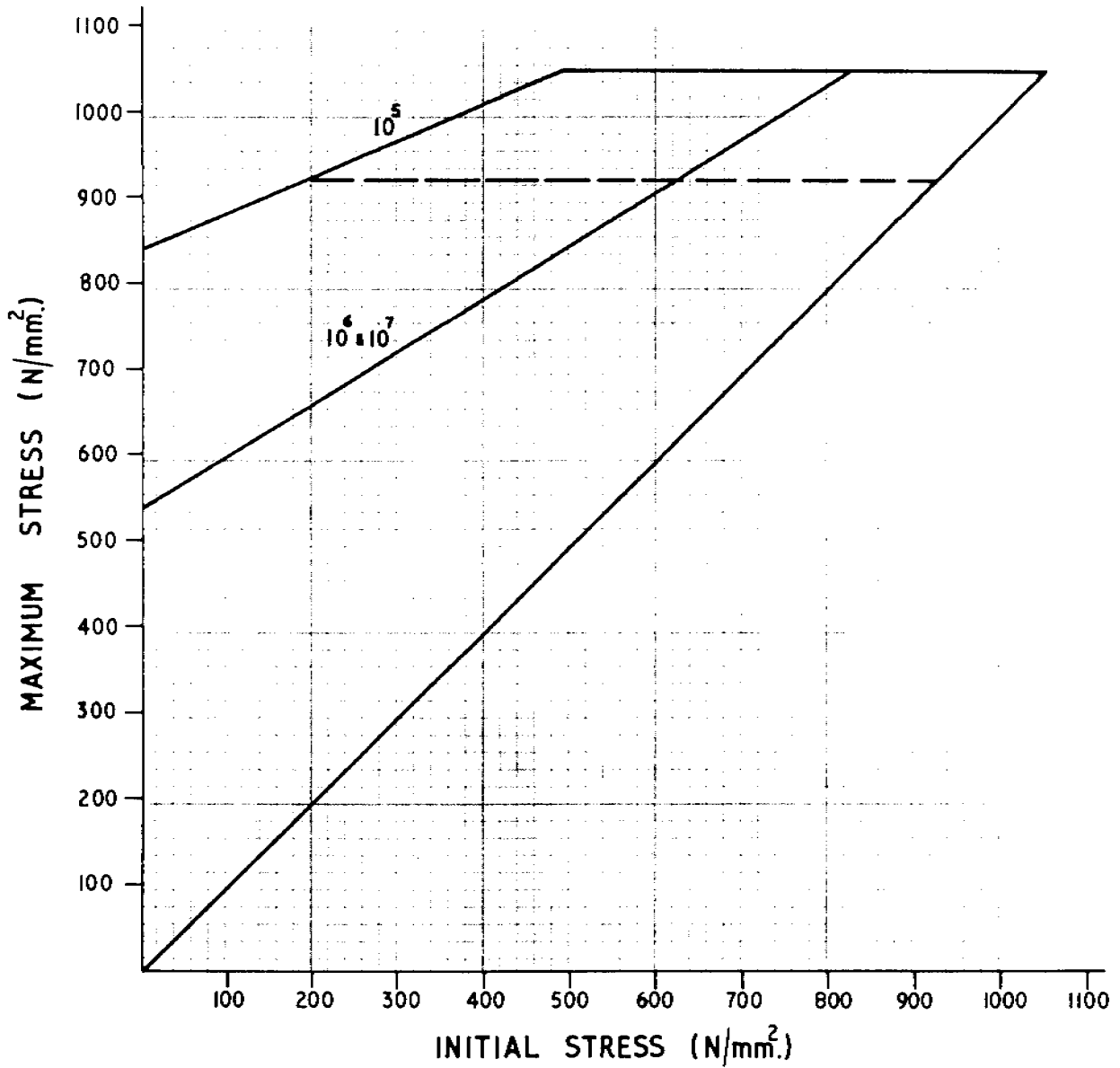


FIG. 8. FATIGUE DIAGRAM FOR PRESTRESSED,
UNPEENED HARD DRAWN PATENTED WIRE
TO B.S. 1408 C RANGE 3

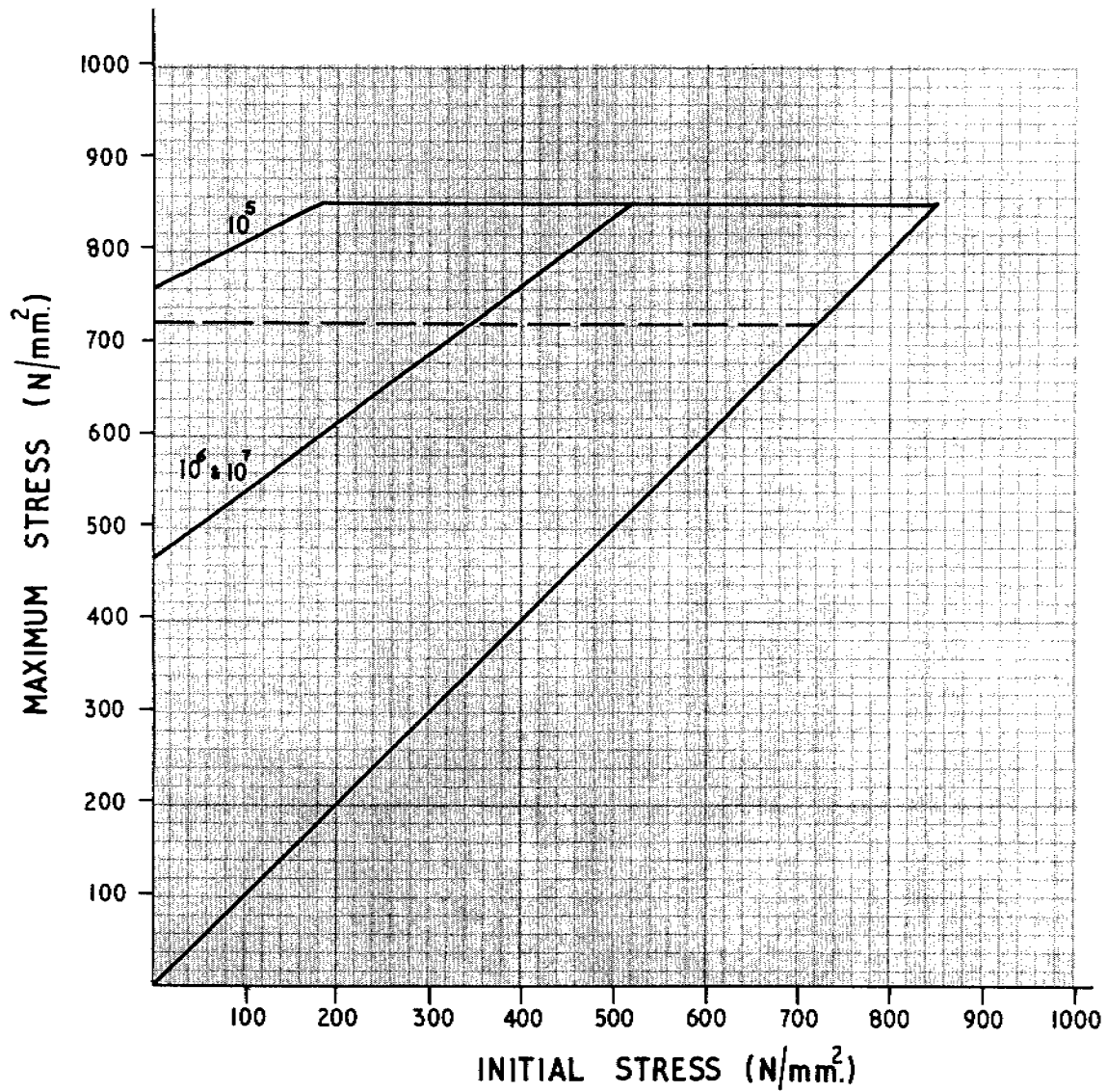


FIG. 9. FATIGUE DIAGRAM FOR PRESTRESSED,
UNPEENED HARD DRAWN PATENTED WIRE
TO B.S. 1408 D RANGE 1

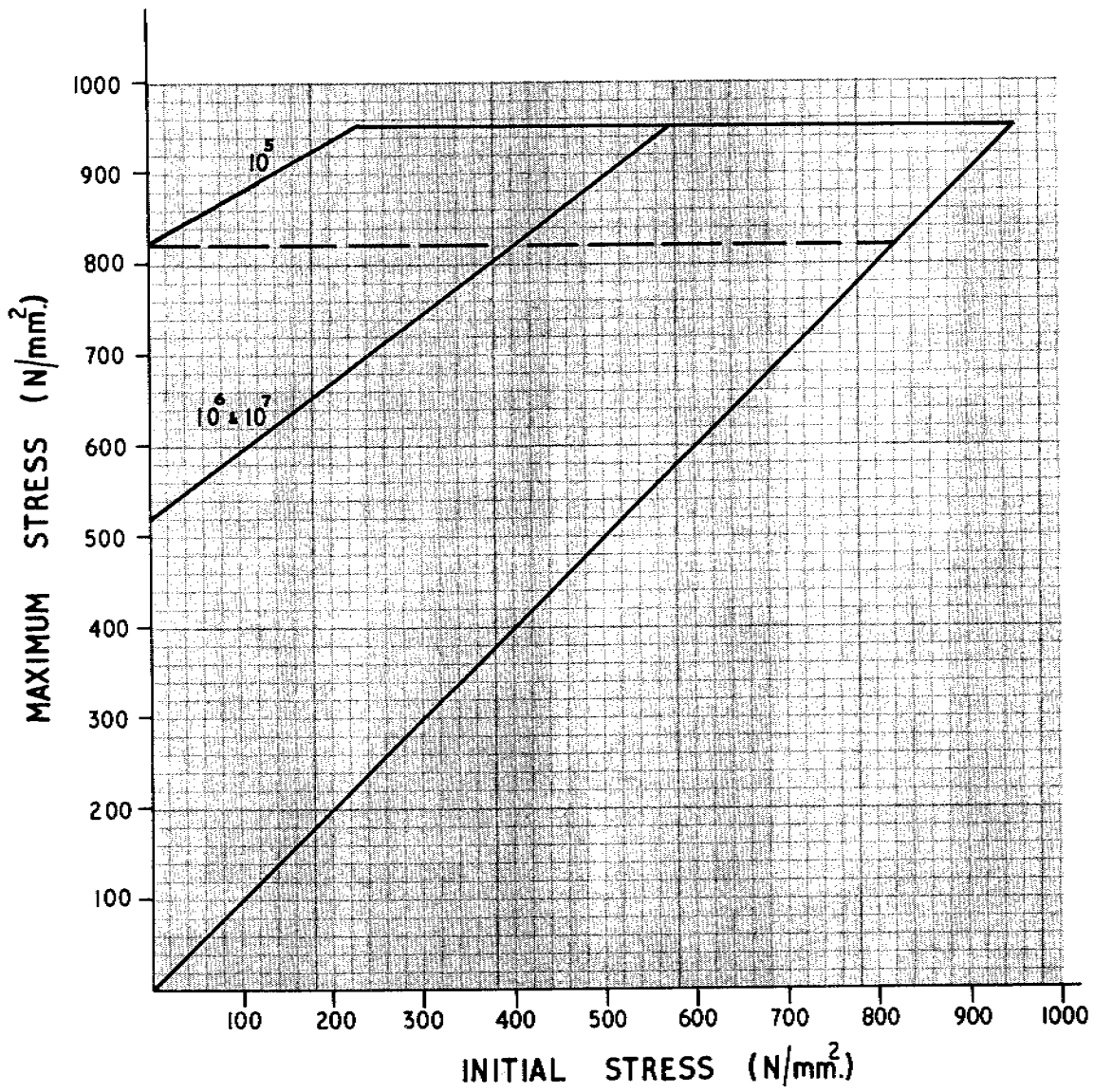


FIG. 10. FATIGUE DIAGRAM FOR PRESTRESSED,
UNPEENED HARD DRAWN PATENTED WIRE
TO B.S. 1408D RANGE 2

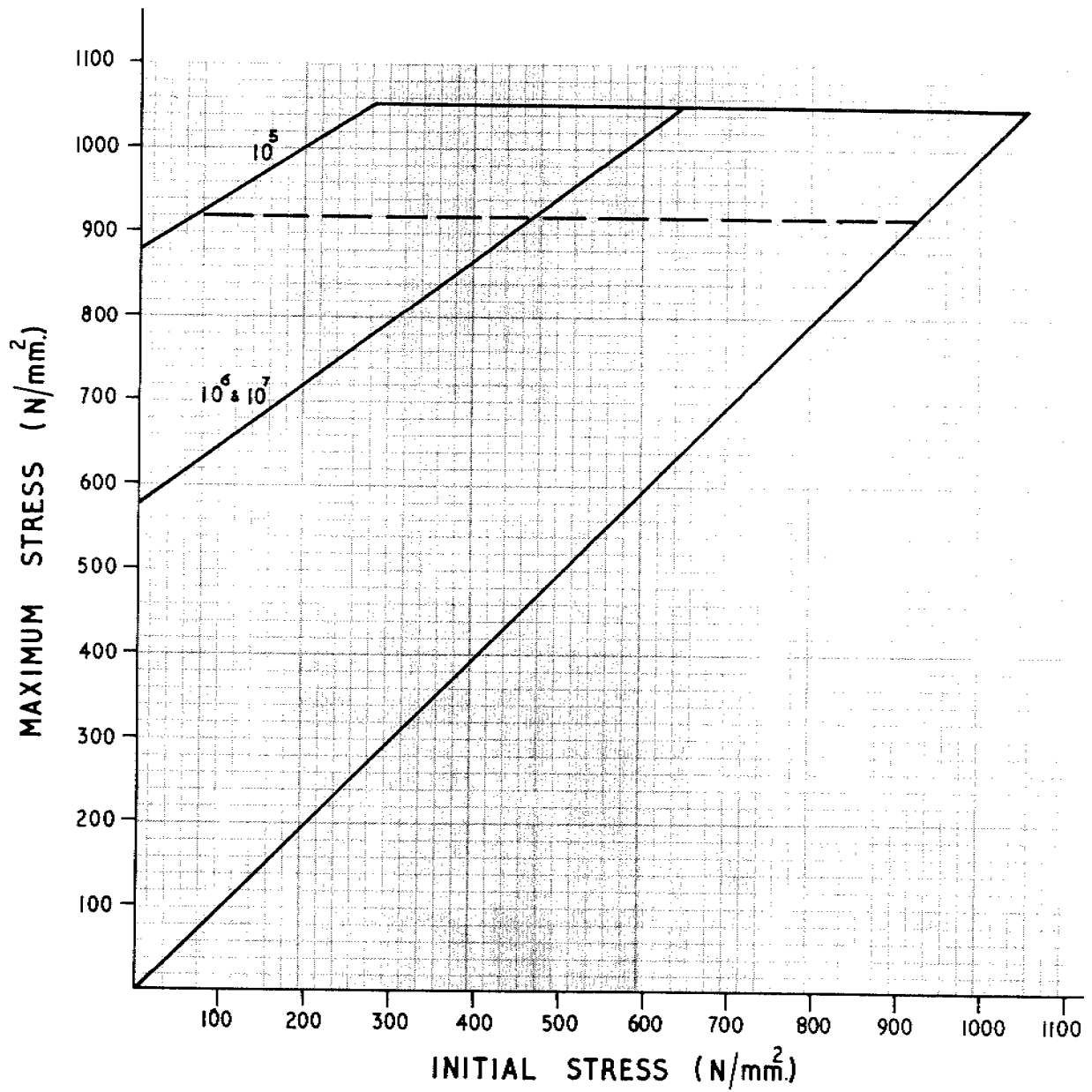


FIG. II. FATIGUE DIAGRAM FOR PRESTRESSED,
UNPEENED HARD DRAWN PATENTED WIRE
TO B.S. 1408 D RANGE 3

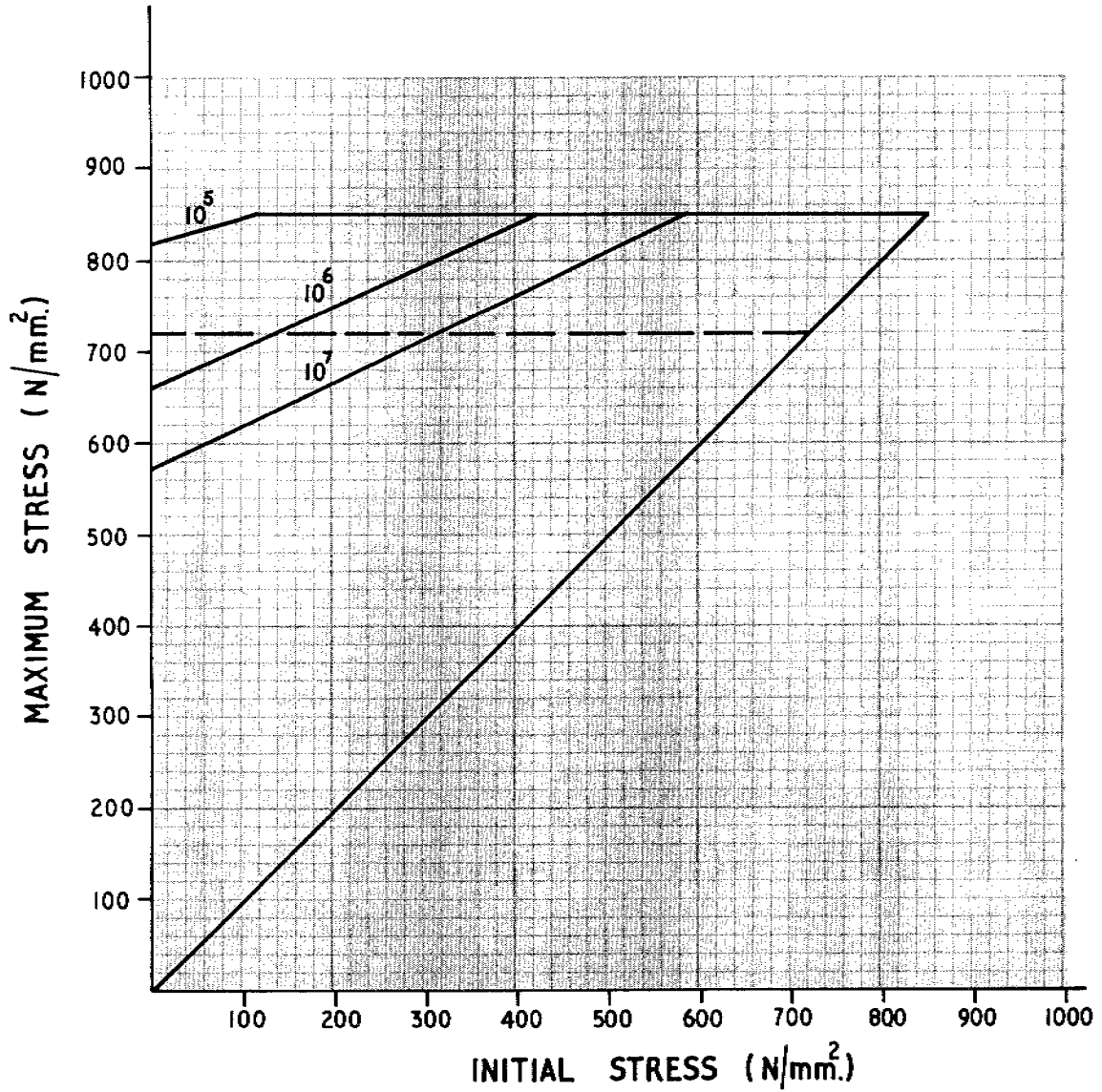


FIG. 12. FATIGUE DIAGRAM FOR PRESTRESSED,
SHOT-PEENED HARD DRAWN PATENTED WIRE
TO B. S. 1408 C RANGE I

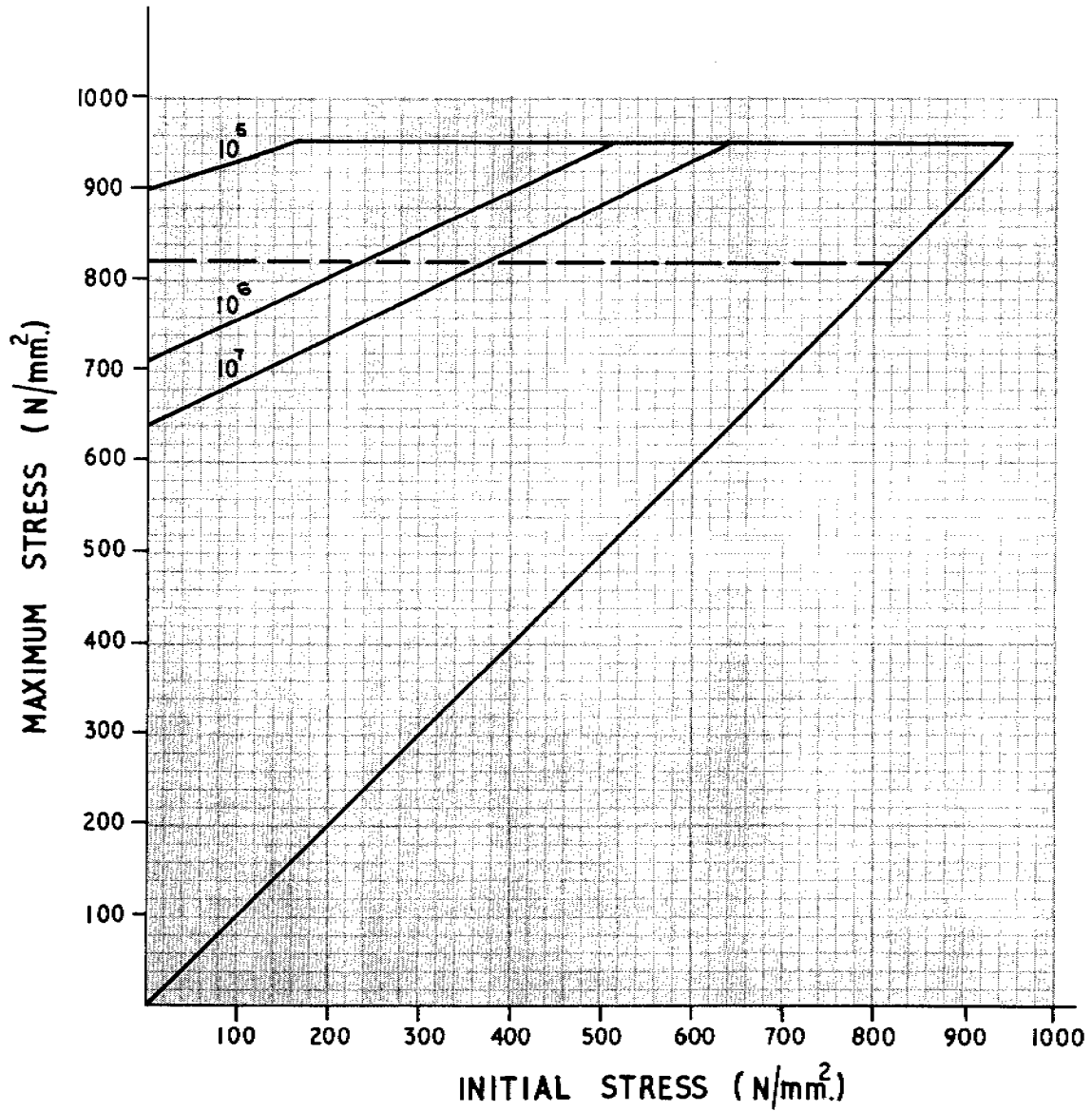


FIG. 13. FATIGUE DIAGRAM FOR PRESTRESSED,
SHOT-PEENED HARD DRAWN PATENTED WIRE
TO B.S. 1408C RANGE 2

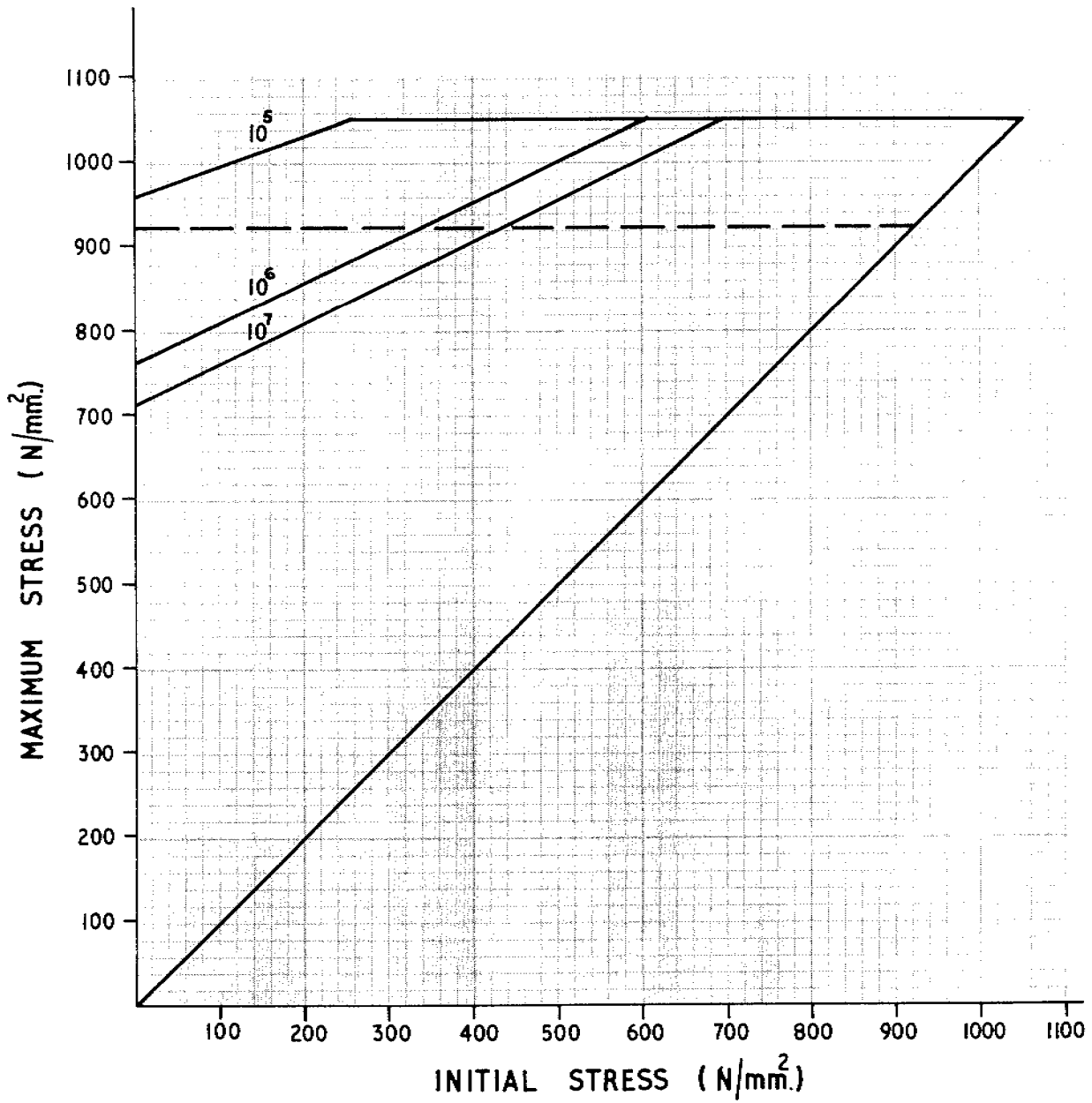


FIG.14. FATIGUE DIAGRAM FOR PRESTRESSED,
SHOT-PEENED HARD DRAWN PATENTED WIRE
TO B.S. 1408 C RANGE 3

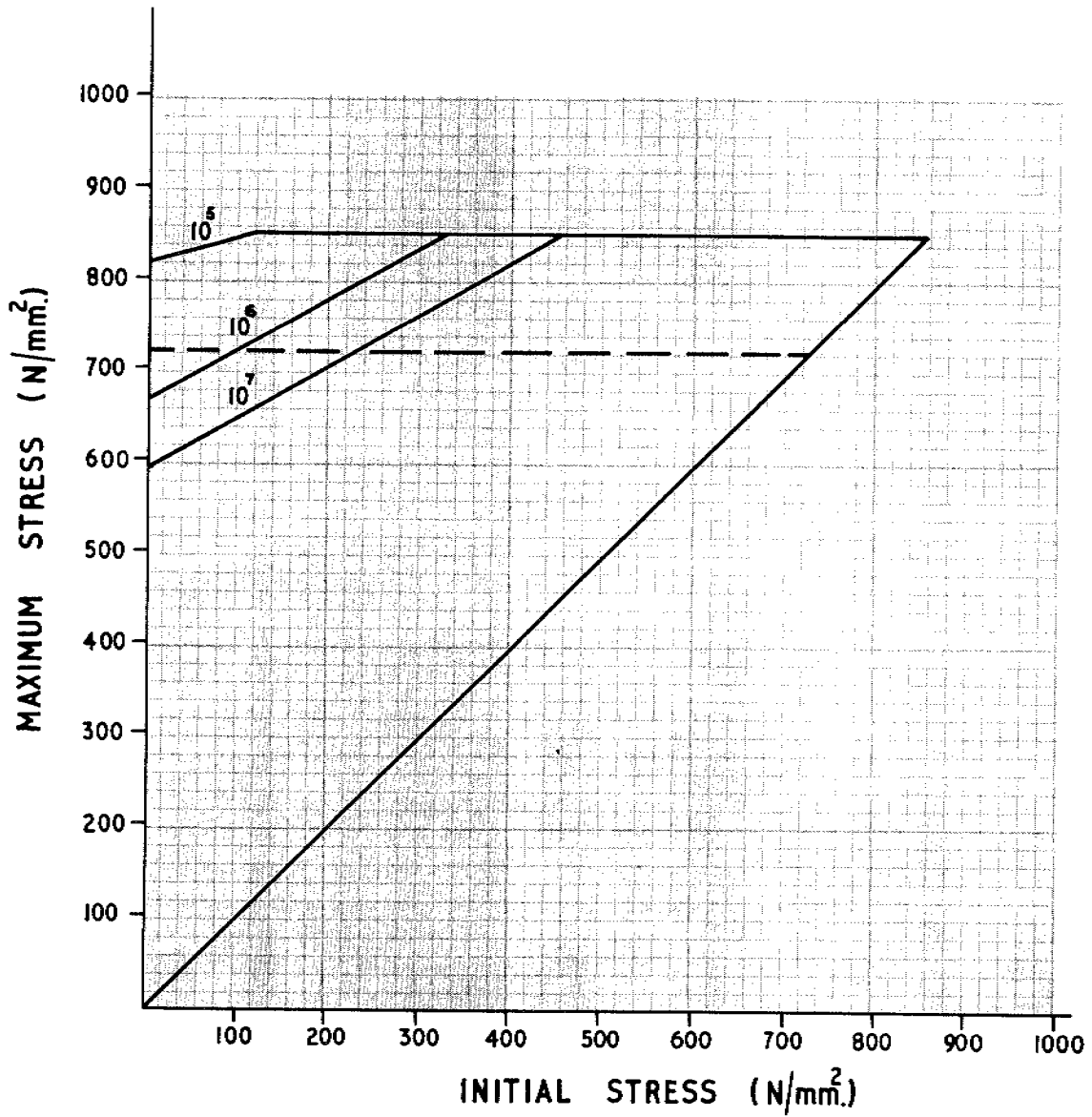


FIG. 15. FATIGUE DIAGRAM FOR PRESTRESSED,
SHOT-PEENED HARD DRAWN PATENTED WIRE
TO B.S. 1408D RANGE I

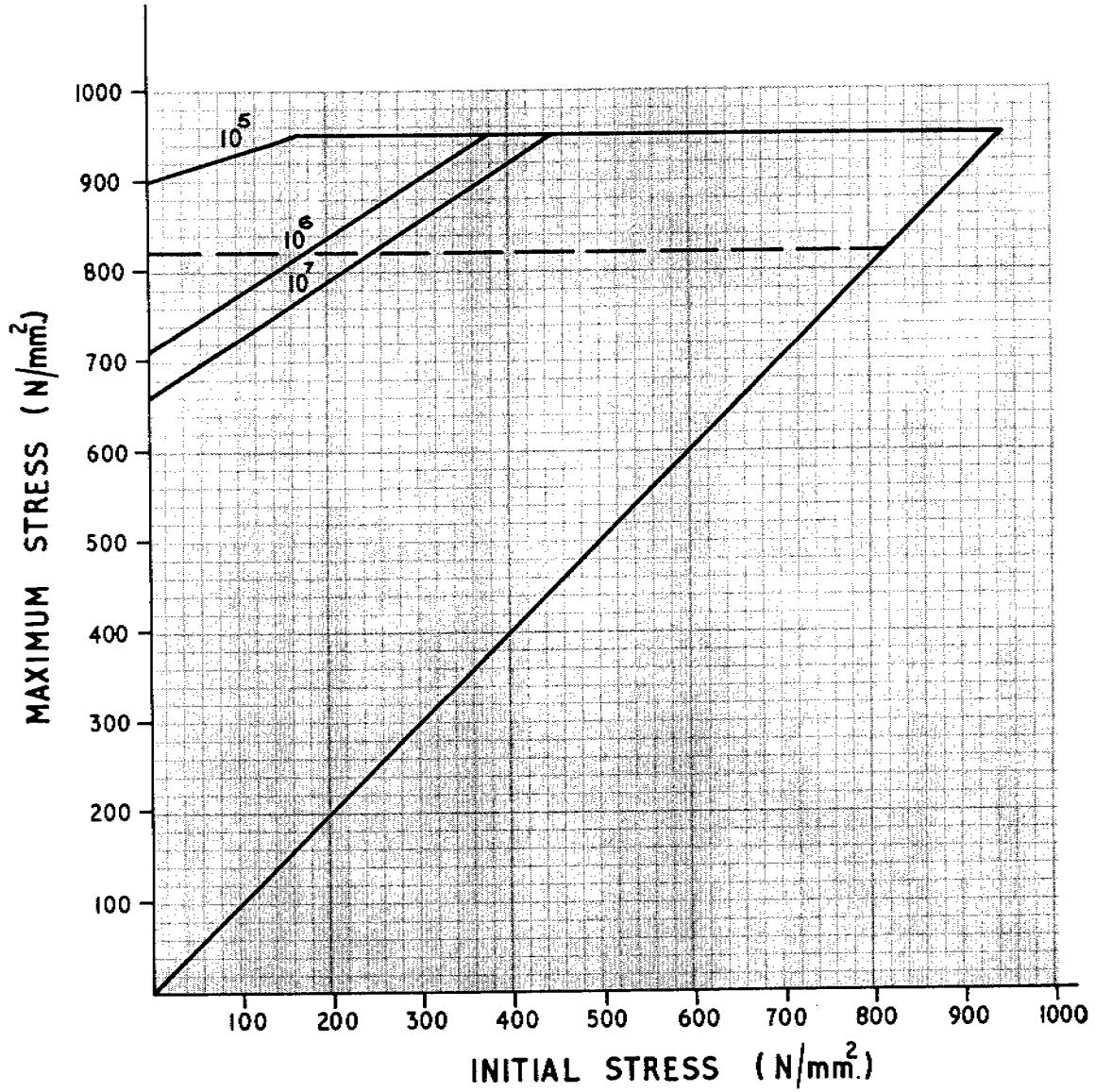


FIG. 16. FATIGUE DIAGRAM FOR PRESTRESSED,
SHOT-PEENED HARD DRAWN PATENTED WIRE
TO B.S. 1408D RANGE 2

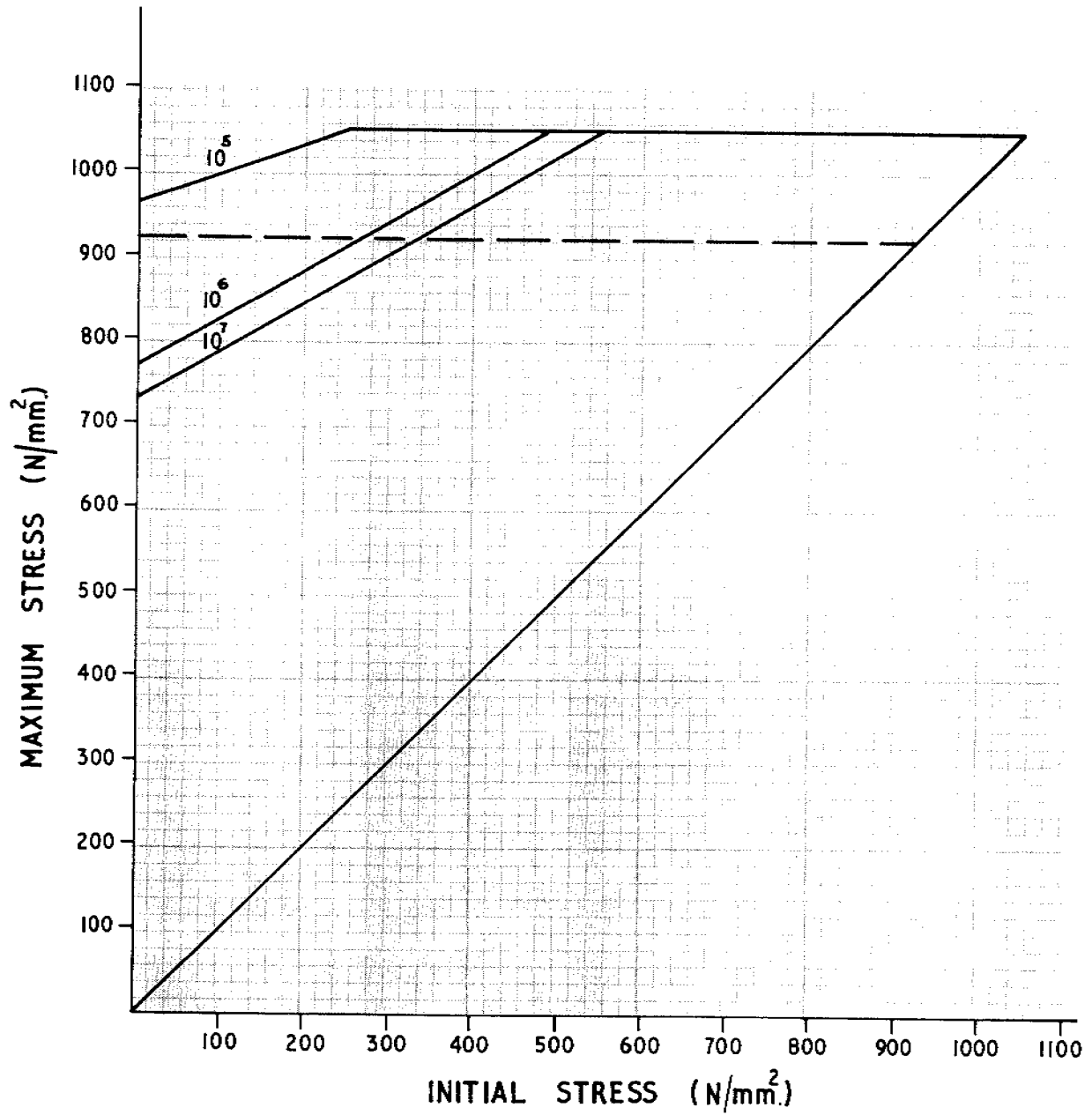


FIG. 17. FATIGUE DIAGRAM FOR PRESTRESSED,
SHOT-PEENED HARD DRAWN PATENTED WIRE
TO B.S. 1408D RANGE 3

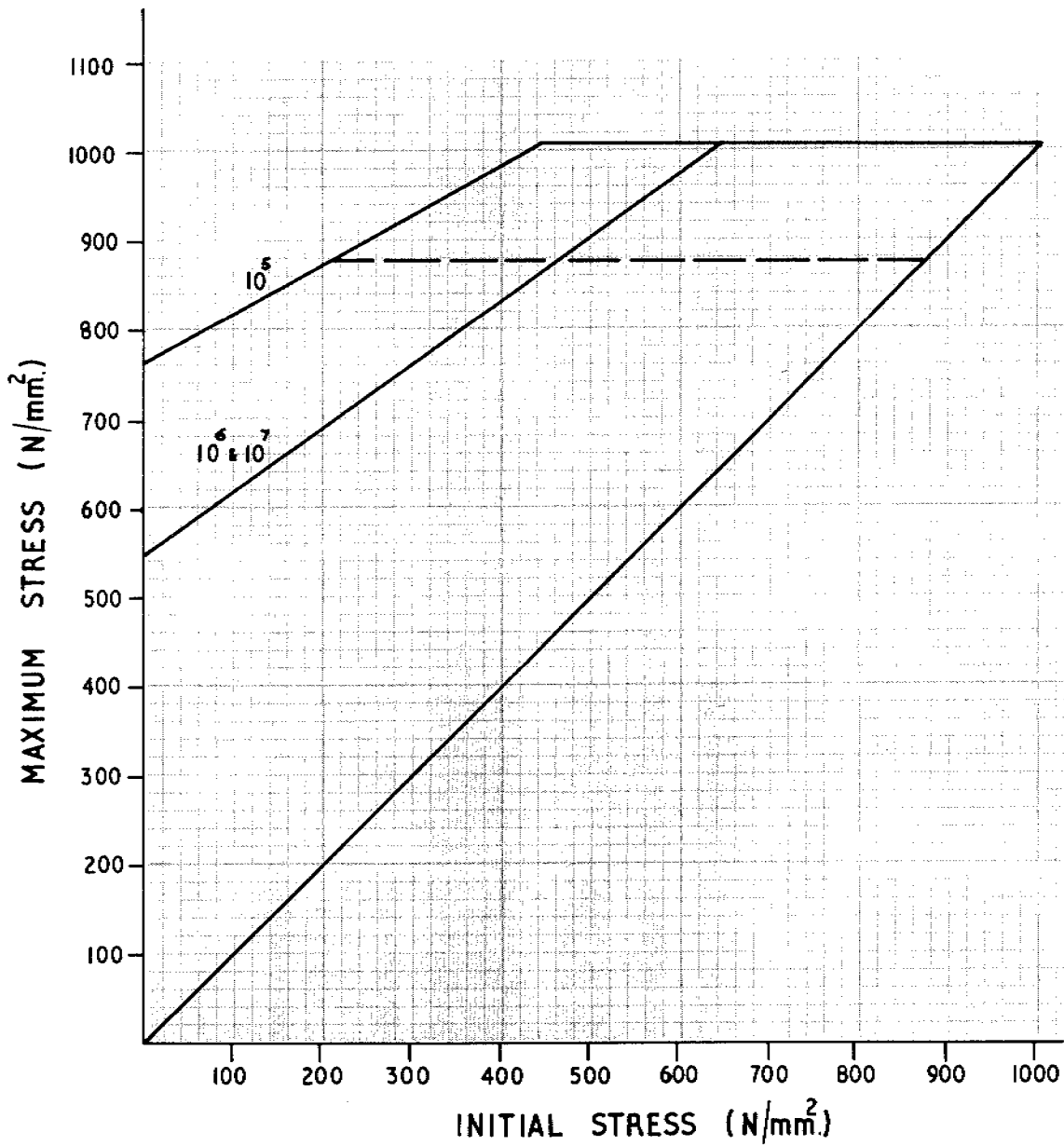


FIG.18. FATIGUE DIAGRAM FOR PRESTRESSED,
UNPEENED OIL-HARDENED AND TEMPERED WIRE
TO B.S. 2803 GRADE I

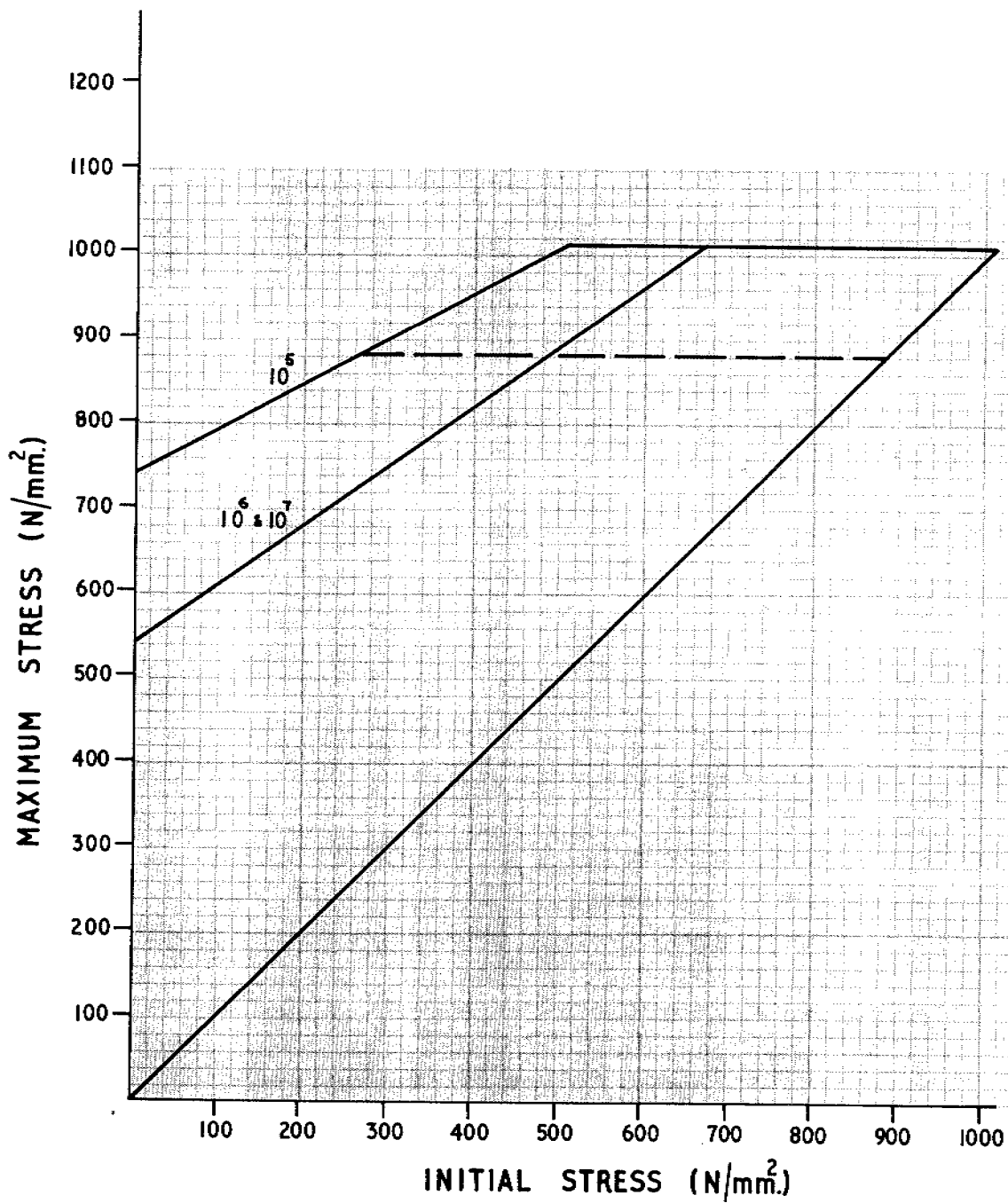


FIG. 19. FATIGUE DIAGRAM FOR PRESTRESSED, UNPEENED OIL-HARDENED AND TEMPERED WIRE TO B.S. 2803 GRADE II

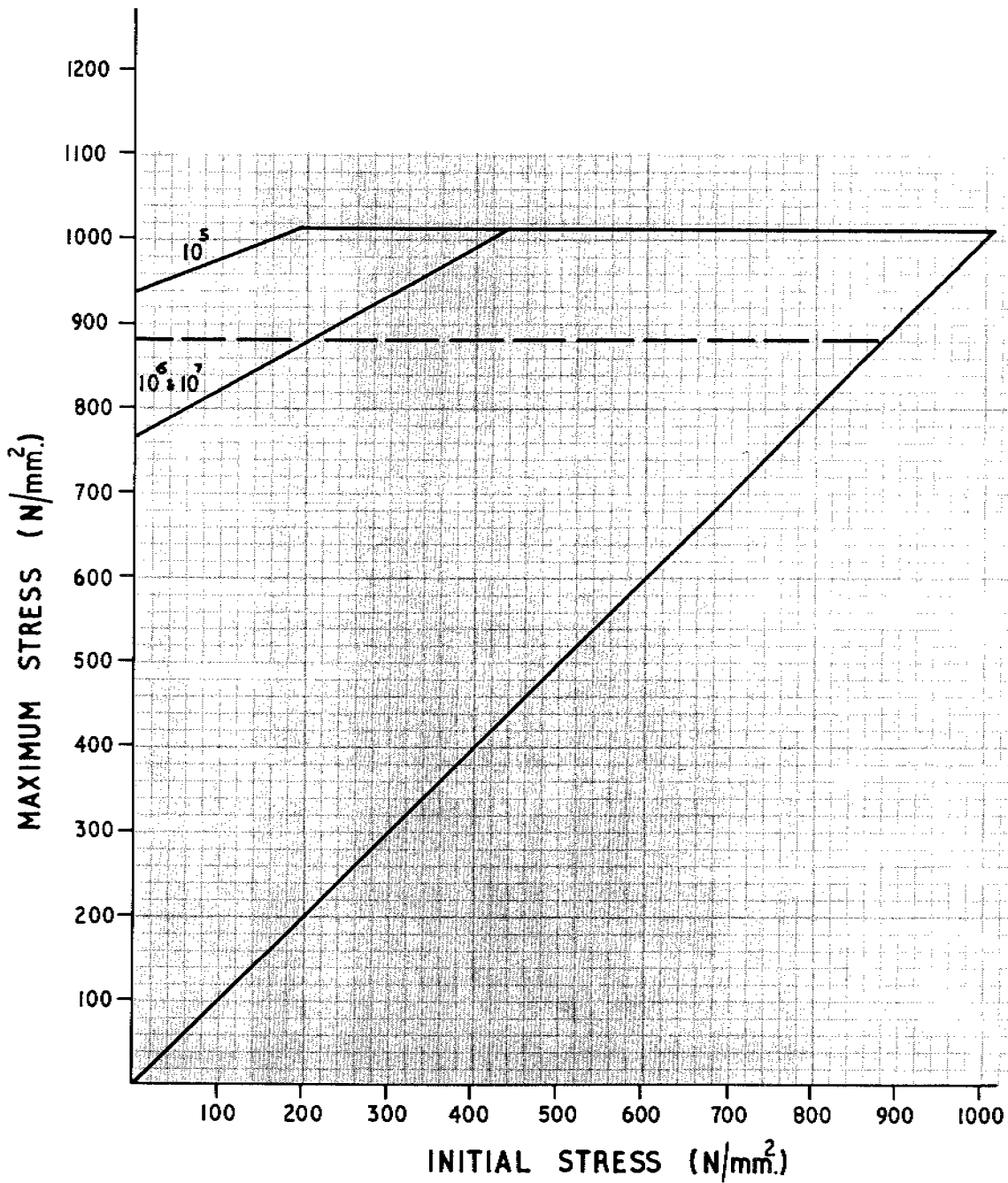


FIG. 20. FATIGUE DIAGRAM FOR PRESTRESSED,
SHOT-PEENED OIL-HARDENED AND TEMPERED WIRE
TO B.S. 2803 GRADE I

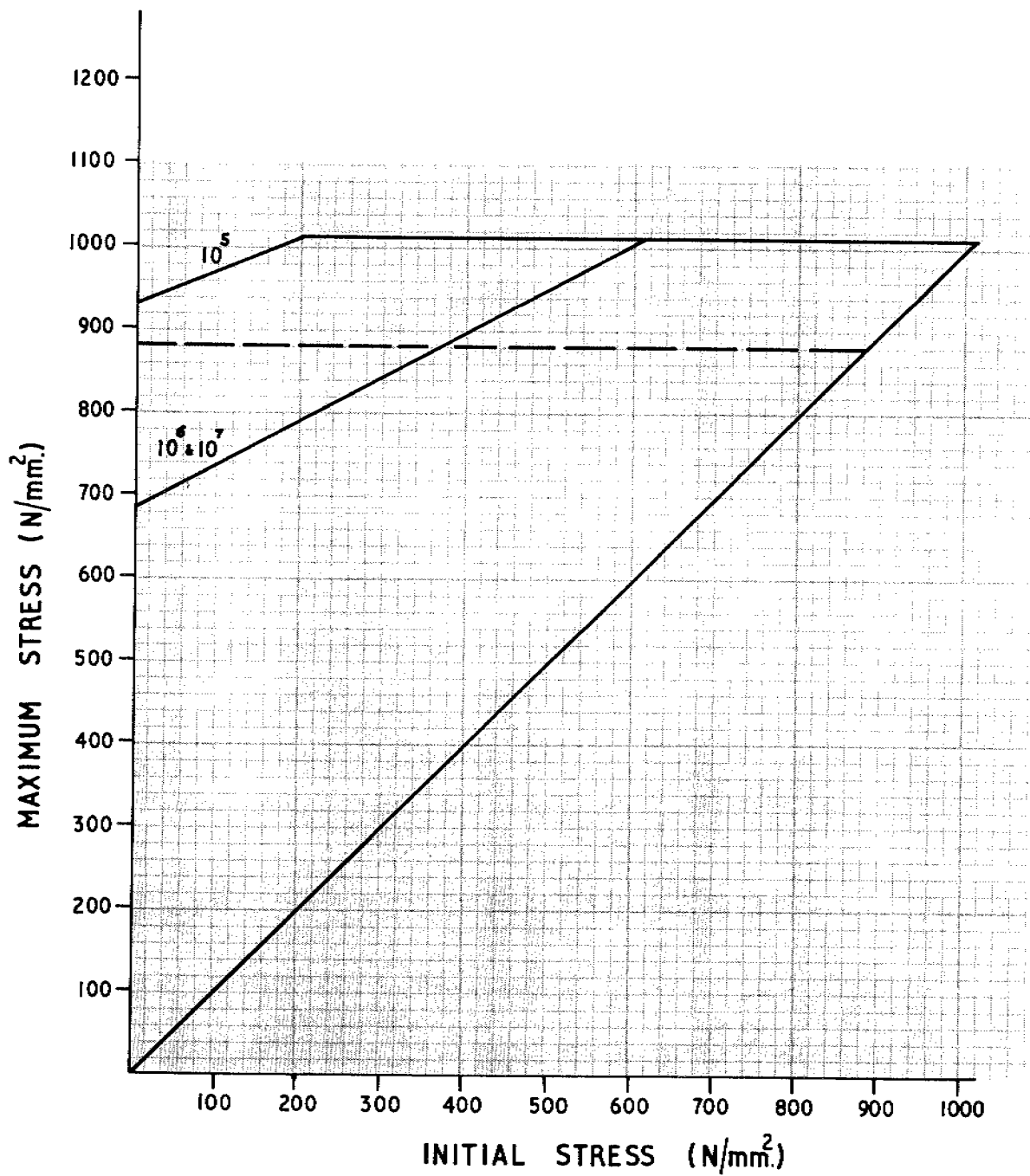


FIG. 21. FATIGUE DIAGRAM FOR PRESTRESSED,
SHOT-PEENED OIL-HARDENED AND TEMPERED WIRE
TO B.S. 2803 GRADE II

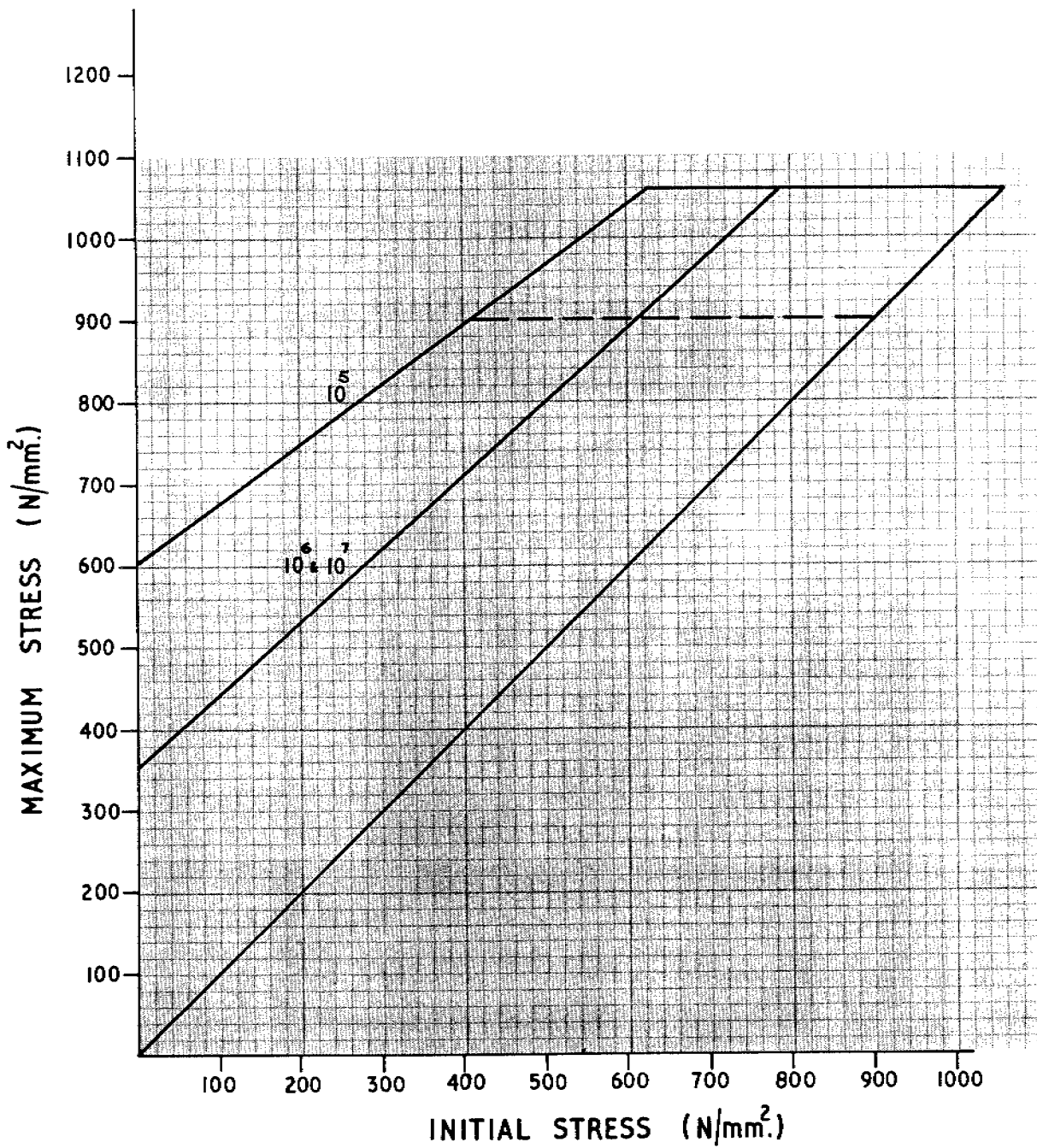
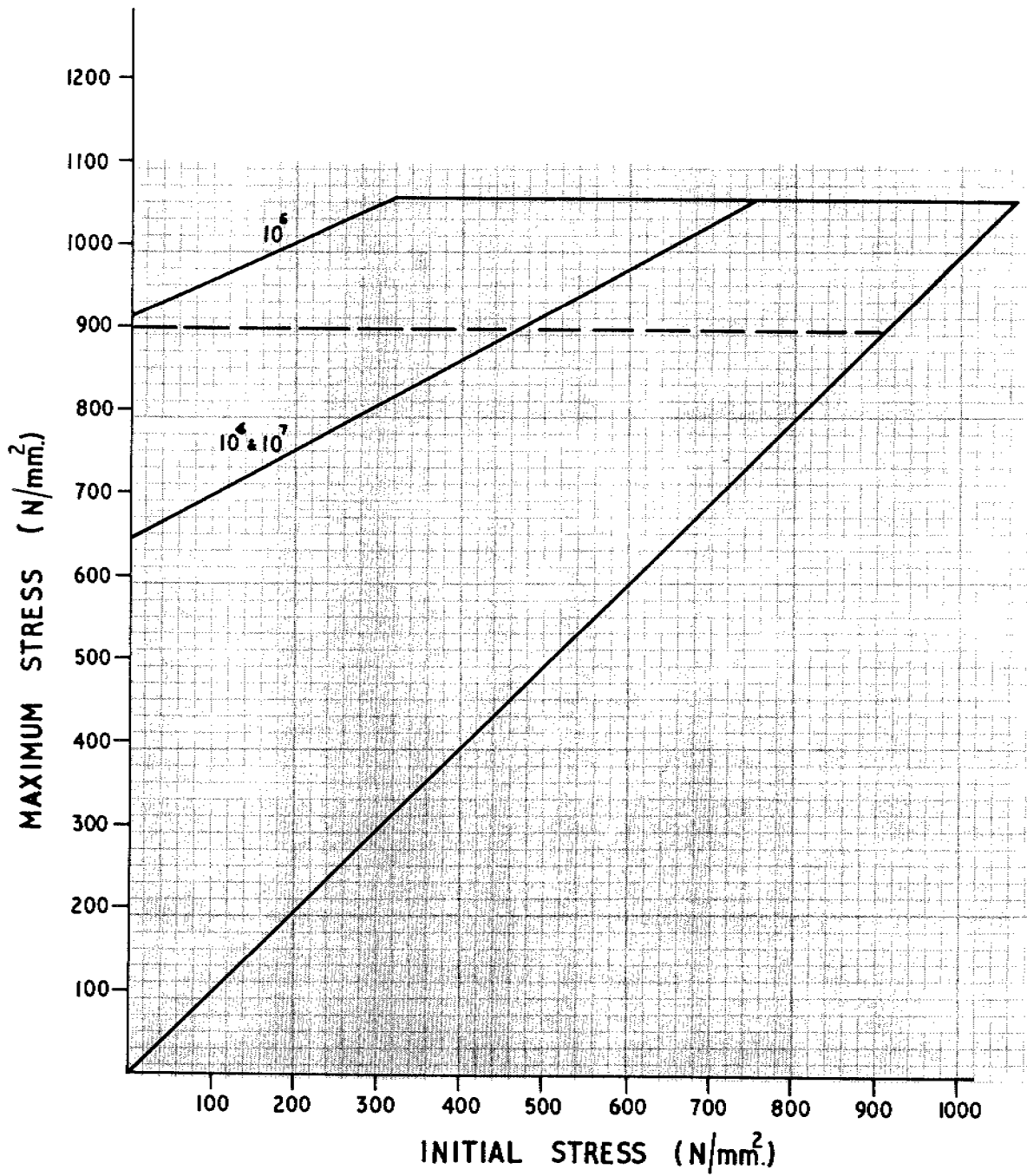


FIG. 22. FATIGUE DIAGRAM FOR PRESTRESSED
UNPEENED, OIL-HARDENED AND TEMPERED CHROME
VANADIUM STEEL En 47 TO B.S. 1429



**FIG. 23. FATIGUE DIAGRAM FOR PRESTRESSED
SHOT-PEENED, OIL-HARDENED AND TEMPERED CHROME
VANADIUM STEEL En 47 TO B.S. 1429**

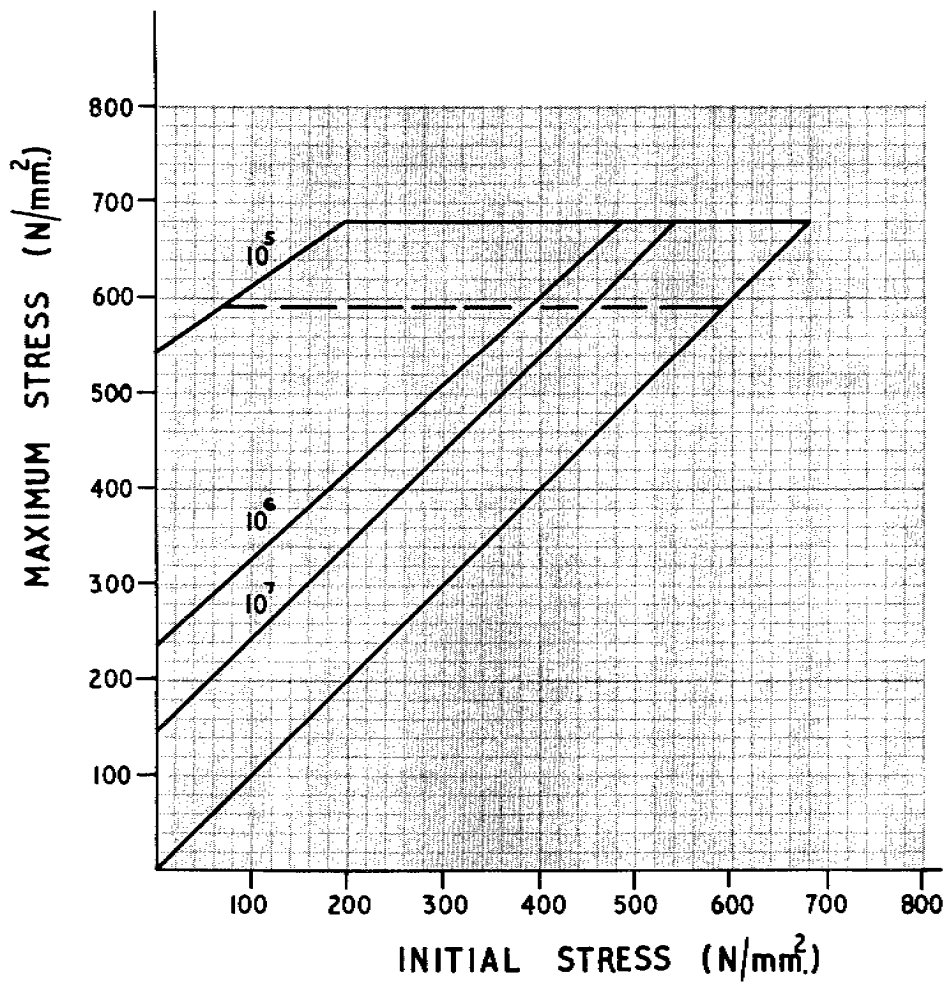


FIG. 24. FATIGUE DIAGRAM FOR PRESTRESSED, UNPEENED HARD DRAWN STAINLESS STEEL WIRE TO B.S. 2056, En 58 A

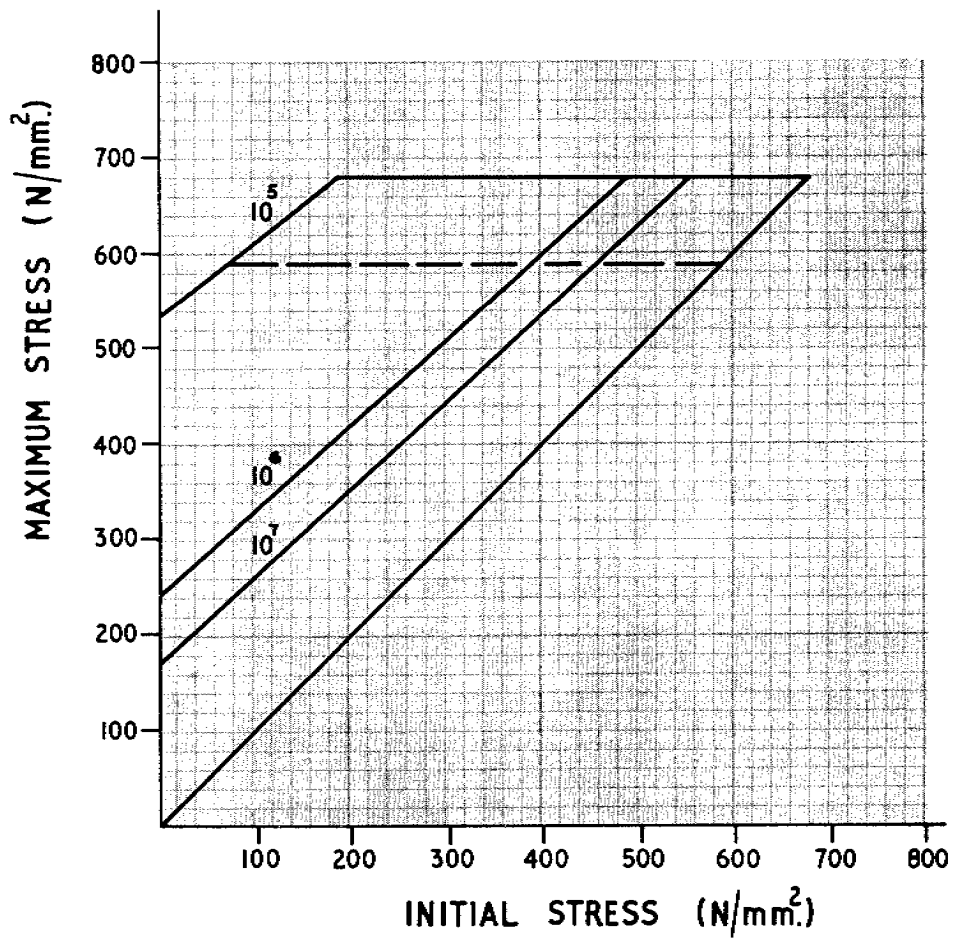


FIG. 25. FATIGUE DIAGRAM FOR PRESTRESSED, UNPEENED HARD DRAWN STAINLESS STEEL WIRE TO B.S. 2056, En 58 J

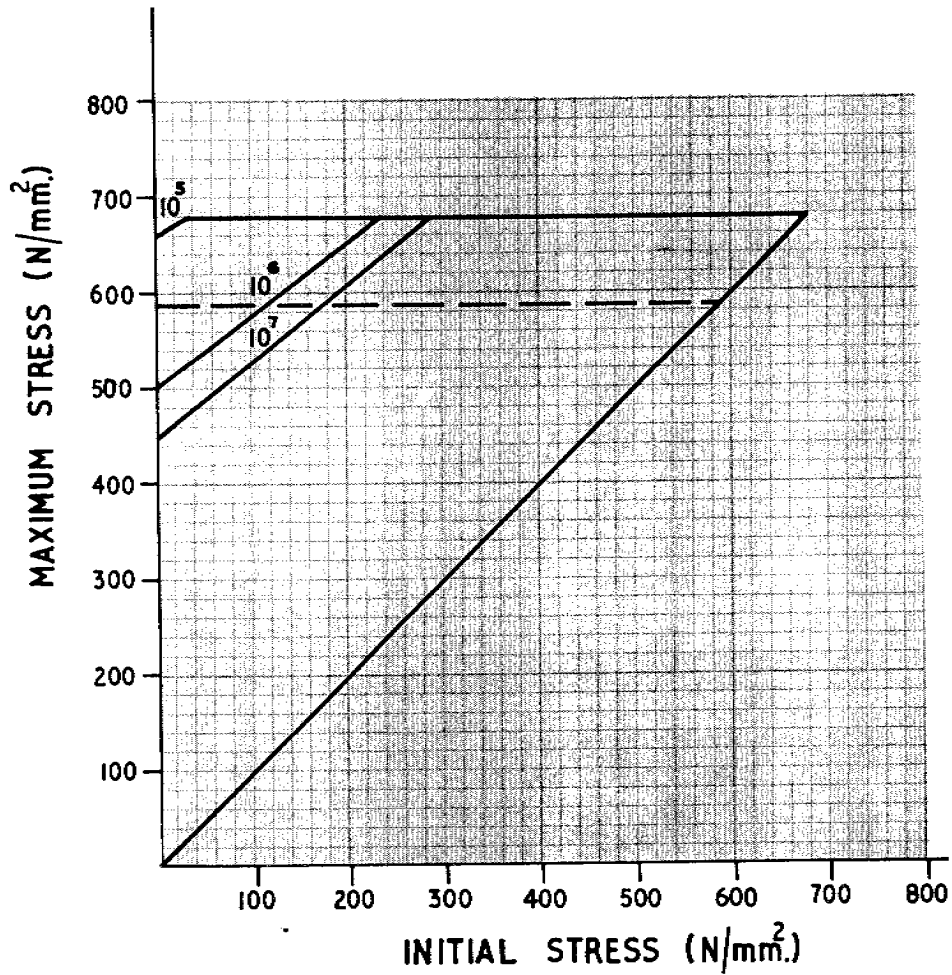


FIG. 26. FATIGUE DIAGRAM FOR PRESTRESSED,
SHOT-PEENED HARD DRAWN STAINLESS STEEL WIRE
TO B.S. 2056, En 58A

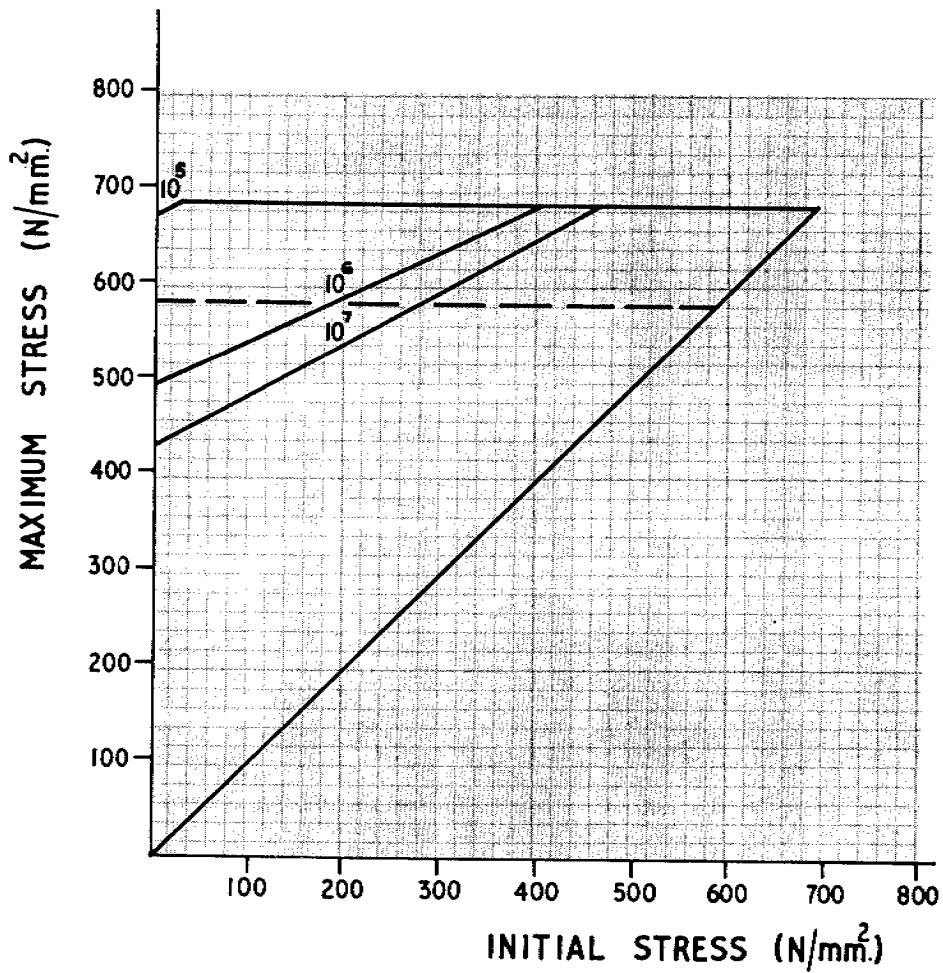


FIG. 27. FATIGUE DIAGRAM FOR PRESTRESSED,
SHOT-PEENED HARD DRAWN STAINLESS STEEL WIRE
TO B.S. 2056, En 58J.