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NAVY DEPARTMENT

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Report of

Tests Made with Optical Stethoscope

developed by

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ANACOSTIA STATION
WASHINGTON, D. C.

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Distribution:
BuEng (1)

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AUTHORIZATION FOR TEST

1. This test was authorized by Bureau of Construction and Repair letter, reference (a).

Reference: (a) BuC&R let.JJ46-1-(29) (S) S87-(19) of 2 September 1937.

OBJECT OF TEST

2. The object of this test is to determine the usefulness of Professor Shrader's optical stethoscope as applied to the detection of harmful laminations in steel plates.

ABSTRACT OF TEST

3. The fusion between halves of a laminated plate is so strong that no difference in the vibration record of a known laminated plate and that of a comparable solid plate could be detected by use of the instrument under test. The conclusion was the same both for free and for forced vibration of the plates.

4. Tests did show that for the case of actual mechanical separation between the halves of a completely laminated plate the difference in rigidity of the plate as compared with the rigidity of a solid plate could be detected by the instrument. Such tests, however, have no application for the detection of actual laminations in steel plates.

Conclusions

(a) Photograph 2 showed that the instrument is suitable for detecting changes in stiffness of structures when the change in stiffness is quite marked (the ratio of stiffness was one to four), but the instrument is not suited for detecting minute changes in stiffness such as a fused lamination would cause.

DESCRIPTION OF INSTRUMENT

5. The instrument under test is a device for picking up and converting mechanical vibrations into the trace of a beam of light upon a ground glass screen and also, if desired, upon a photographic film. By means of a motor arrangement, the trace of the beam of light is caused to show both amplitude and wave form. The conversion of mechanical vibration into a trace of a beam of light is accomplished by having a diaphragm which responds to changes in air pressure oscillate a spindle upon which is mounted a small mirror. The inertia of the moving parts, though small, is enough to make the outfit less sensitive to high frequencies than to low frequencies.

METHOD OF TEST

6. The first tests were made with forced vibrations as set up by an electric hammer pounding directly upon the plate in one set of tests and through a rubber pad in another set of tests. It was found that the rubber pad was necessary to get a more nearly constant hammer blow upon the plate. Even so, however, it was found that the method of forced vibrations did not give reasonably reproducible patterns. Any desired average strength of hammer blow could be obtained by varying the voltage supplied to the hammer.

7. The next series of tests was made by pounding at intervals sufficiently far apart to allow study of the plates under free vibration. Two sets of this second series of tests were made.

8. The first set of free-vibration tests was made upon two plates laid together, for comparison with a single plate of the same total thickness. These tests were made to see how well the instrument would detect such an obvious difference in rigidity between the stack of two plates and the completely solid plate.

9. The next set of free-vibration tests was made upon two separate plates, one of which was known to be laminated throughout and the other of which was known to be solid throughout. These plates were each 1/4 inch by 6 inches by 24 inches. The one plate, though known to be laminated both as revealed by magnetic studies and as shown by etching, was fairly well fused together.

DATA RECORDED DURING TEST

10. A sample of the lack of steadiness in amplitude when forced vibration was used is shown in Fig.1.

11. In Fig. 2 is shown the result of a test upon the stack of two plates as compared with a single solid plate. The photograph shows that the period of free vibration for the stack of plates is longer than for the solid plate, in qualitative agreement with theory. According to theory the ratio of frequencies should be one to two, but the ratio given by the photograph is around five to eight.

12. In Fig.3 is shown a record of free vibration for the laminated plate, and in Fig. 4 is shown a comparable record of free vibration for the solid plate.

DISCUSSION OF PROBABLE ERRORS

13. The photographs of the present report may be accepted as reasonably conclusive evidence that the instrument under test is not a promising device for detecting fused laminations in steel plates. It is recognized that the character of the photographic record will depend to some extent upon getting identical hammer blows; upon the type of cushioning, if any, used for mounting the plate and also for applying the exciting force; and upon the mass and design of the pick-up tube as well as upon other design considerations. Since, however, the present tests were not meant to be exhaustive, but sample tests, the evidence which was obtained may be regarded as reasonably reliable and reasonably conclusive.

RESULTS OF TEST

14. Preliminary experiments with the optical stethoscope revealed that the instrument is much more responsive to low frequency than to high frequency impulses. The instrument may accordingly be described as primarily an instrument for the observation and recording of subsonic frequencies, instead of sonic frequencies. Now, the change in stiffness of a plate due to a fused lamination is - however real - so minute that the subject type instrument appears quite unsuited for detecting such defects in plates. In other words, what the instrument detects is the vibration of the plate due not to any differential effects, but the vibration due to the whole effect (at point of pick-up) of the exciting force.

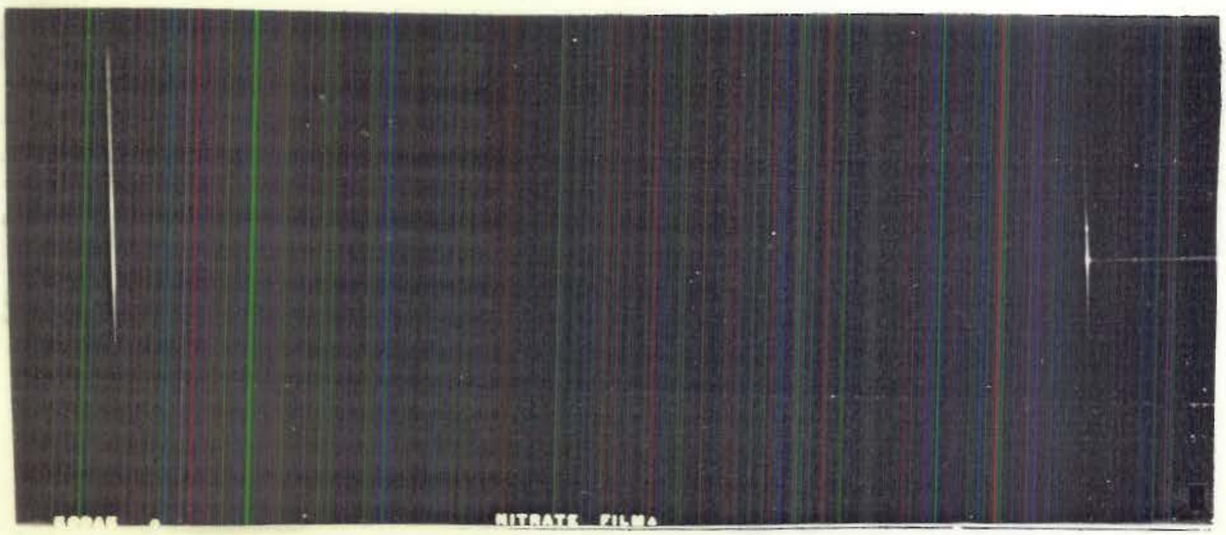
CONCLUSIONS

15. Photograph 2 showed that the instrument which was tested is suited for detecting changes in stiffness of structures when the change in stiffness is quite marked (the ratio of stiffness was one to four), but the instrument is not suited for detecting minute changes in stiffness such as a fused lamination would cause.

Appendix

"Results of Mr. Ripley's simple tests are in agreement with earlier tests made by the Sound Division. The sound or vibration recorded by the stethoscope placed at any position along the plate is a summation at that location of the complicated standing wave system set up in the plate by the vibrating or other type of energizing source. Its form must be influenced slightly by the presence of a lamination in the plate and by the size, shape, and location of the laminated area, but the relation between cause and effect is too obscure to permit locating the fault or even predicting its presence."

H. C. Hayes,
Superintendent,
Sound Division



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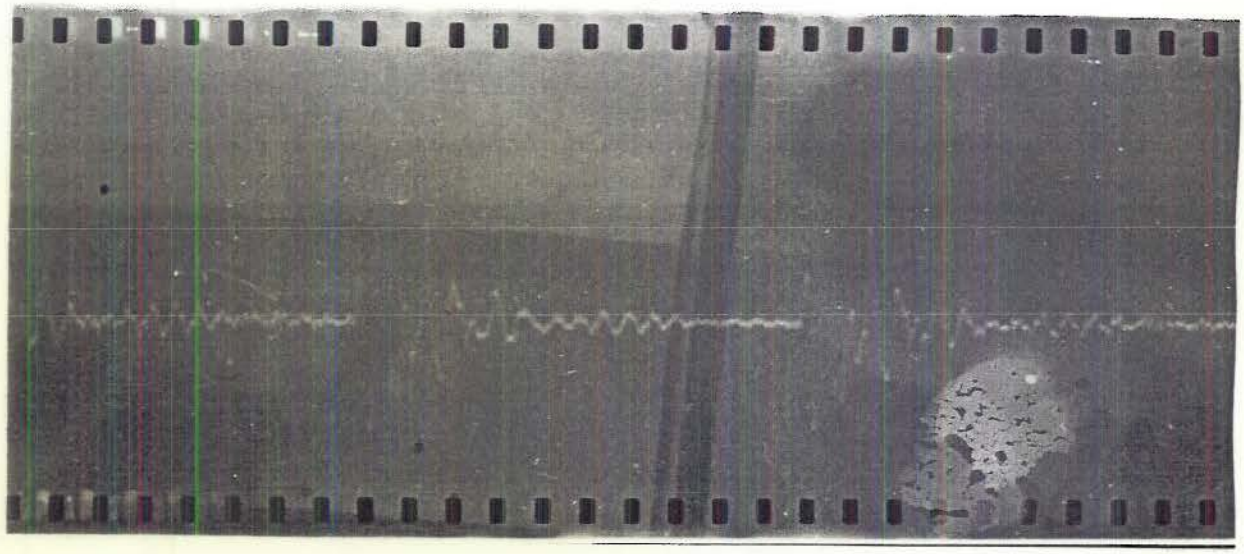

Fig. 4

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