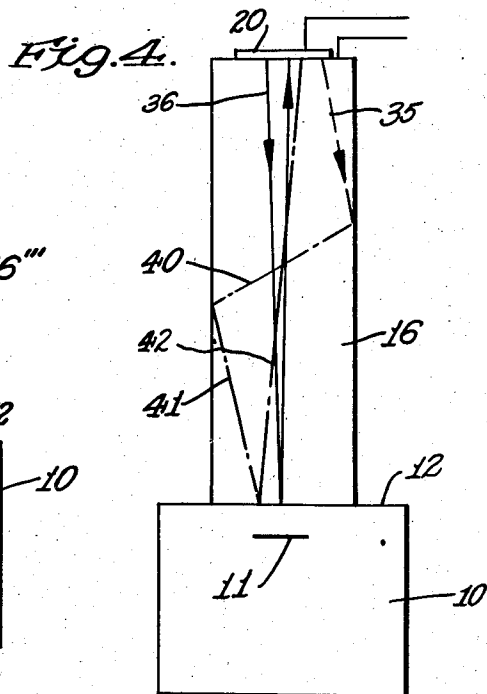
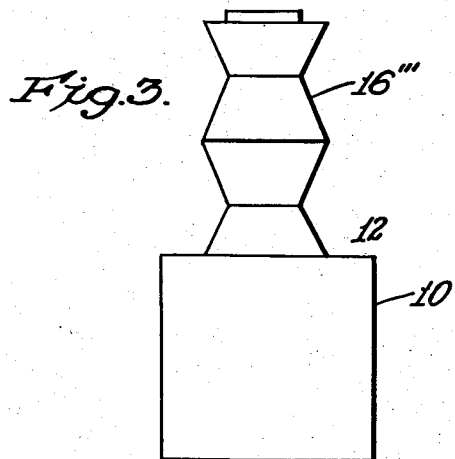
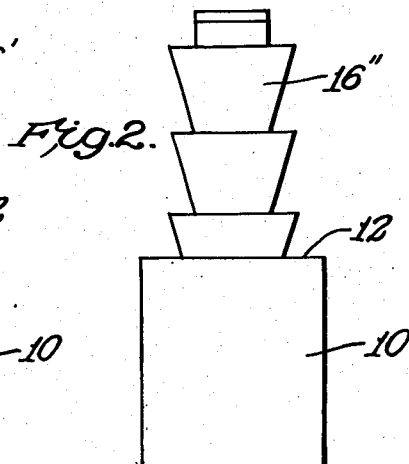
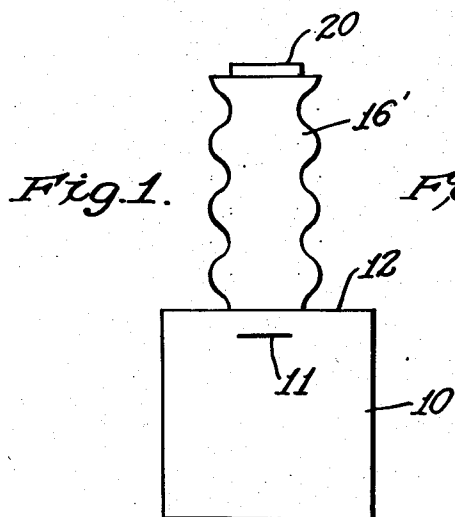


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SUPERSONIC INSPECTION FOR FLAWS LYING NEAR
THE SURFACE OF A PART
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SUPERSONIC INSPECTION FOR FLAWS
LYING NEAR THE SURFACE OF A PART

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This invention relates to the supersonic inspection of materials particularly in those cases where the flaw to be detected lies near the surface of the part to be inspected. In the patent to Firestone, No. 2,280,226, granted April 21, 1942, there is disclosed one form of supersonic inspection device which consists in sending, by means such as an electro-acoustic transducer, including a quartz crystal, a short supersonic wave train into the part to be inspected and detecting, by a similar electro-acoustic transducer, the reflection of said wave train from any flaws which may be present in the interior of the solid. In the form of the invention disclosed in said patent, some difficulty is experienced in those cases where the flaws to be detected lie closer to the sending crystal than $\frac{1}{2}$ ". The reason for this difficulty lies in the fact that the waves reflected back to the sending point by a defect lying near the surface start arriving before the detecting equipment has recovered from the shock of the transmission of the wave train.

One solution for the difficulty described above is disclosed in the co-pending application of Floyd A. Firestone, Serial No. 606,494, filed July 23, 1945, now Patent No. 2,467,301, issued April 12, 1949, and consists in providing a member interposed between the sending crystal and the entering surface of the solid part to be tested whereby the time interval which elapses between the transmission of a wave train and the receiving of said wave train after being reflected by a defect lying close to the surface of the solid part is increased to the desired degree. This desired degree is such increase of time that the reflection from the defect will be sufficiently spaced in time from the transmission of the wave train to permit the detecting apparatus to recover from the shock of transmission.

When it is attempted to interpose a member as described above for the purpose of increasing the time interval between transmission of the pulse and reception of reflections from a defect within the object of the test, it is found that difficulty arises due to the fact that certain of the waves strike the sides of the interposed member and eventually, by a series of reflections find their way back to the receiving element. These subsidiary reflections frequently arrive while the reflections from reflecting surfaces within the solid part are still being received and thus tend to obscure reflections which may be an indication of the presence of a defect within the material. In said co-pending application it was sought to overcome this difficulty by making the interposed

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member of substantial width so that the subsidiary reflections from the sides of the interposed member would have a considerably longer path to travel and, therefore, would arrive sufficiently later than reflections from a defect within the part under test so that distinction could be made between the defect and the subsidiary reflections. However, it is not always feasible to provide an intermediate member of such substantial width and usually it is desirable to have the interposed member of minimum width and usually no greater width than the crystal transducer.

It is one of the principal objects of this invention, therefore, to provide an interposed member between the sending crystal and the part under test which may be of no greater width than the crystal transducer and which will, nevertheless, not deliver to the receiving element any substantial quantity of subsidiary reflections which can interfere with reflections from a defect within the part under test.

Further objects and advantages of this invention will become apparent in the following detailed description thereof.

In the accompanying drawings,

Fig. 1 is a front elevation illustrating one form of intermediate member interposed between a wave transmitting element and the solid part under test.

Fig. 2 is a view similar to Fig. 1 but showing a modified form of intermediate member.

Fig. 3 is a view similar to Figs. 1 and 2 showing still another modified form of intermediate member.

Fig. 4 is a diagrammatic view illustrating the nature of the problem which this invention seeks to solve.

Referring first to Fig. 1, it is desired to test a solid part 10 for flaws such as the one indicated at 11 which may lie adjacent to surface 12 of the solid part. In applying the invention shown in the Firestone Patent No. 2,280,226 a piezo-electric crystal 20 would be applied to surface 12 and a supersonic wave train or pulse would be transmitted into the solid 10. Such an arrangement, however, would cause the wave train to be reflected back from the flaw 11 in such short time interval that the transmission of the wave train will not have been completed by the time the reflected wave train has reached the receiver. The receiver may be another crystal such as 20 or the same crystal may be employed for both sending and receiving. Therefore, if flaws lying adjacent the surface 12 are to be tested, some method and means must be

provided for increasing the time interval which elapses between the sending of the wave train and the receiving of the reflection thereof from flaws such as flaw 11 located adjacent the surface of the solid trough through which the transmitted waves enter.

One solution of this problem is disclosed in the said co-pending application of Firestone wherein there is interposed between the surface 12 and the sending crystal 20 an intermediate member of some material which conducts supersonic waves. It will now be apparent that the wave train generated by sending crystal 20 must traverse the intermediate member before entering the solid 10 and before reaching the flaw 11. The length of the intermediate member is so selected that the time interval which elapses between the sending of a wave train and the receiving of reflections thereof from the flaw 11 will be sufficient to permit the transmitted wave train to be completed before reflections from flaw 11 are received and will permit the detecting equipment to recover from the shock of transmission.

One difficulty which may arise in the above described solution will become apparent by reference to Fig. 4. Under certain operating conditions, some of the transmitted wave trains 35 will radiate longitudinally as indicated by the dash lines and on striking the side walls of the interposed member 16 will give rise to a shear wave 40 which on striking the opposite wall is again transformed in part into a longitudinal wave 41 which strikes the surface 12 of the solid part 10 and is again reflected back in the form of a beam 42 to the crystal 20. The reflections shown by the dash line represent only one subsidiary reflection and other subsidiary reflections will arise from shear waves having travelled across the member 16 two, three or more times. Since the shear wave thus generated in these subsidiaries travels only about half as fast as the longitudinal wave, the total time consumed by the subsidiary wave from the time it is generated until it returns to crystal 20 is considerably increased relative to the main longitudinal beam shown in the full lines 36 since the latter goes straight down and back. The longer time consumed by the subsidiary reflection may produce an indication which interferes with the indication from the flaw. In other words, the time of travel of the subsidiary reflection may be substantially the same as the time of travel of the main beam from the crystal 20 to the flaw and return.

In said co-pending application, one solution for this difficulty is disclosed, i. e. by making the lateral dimension of the intermediate member 16 large. In this way the time interval required by the subsidiary reflection to return to the crystal 20 is increased sufficiently so that said subsidiary reflection will be received after reflections from the flaw have been received. Another advantage of making the lateral dimension large is that the number of subsidiary reflections is cut down.

However, it frequently occurs that the use of an intermediate member of relatively large lateral dimension is not desirable or even possible and it is essential that the lateral dimension of the intermediate member be no greater than that of the crystal transducer. In order to solve the problem of eliminating interfering subsidiary reflections, there is disclosed herein a solution, one

form of which is shown in Fig. 1 wherein the sides of the intermediate member 16' are so formed as to provide a multiplicity of different reflecting surfaces so that the subsidiary reflections, instead of having a well defined path as disclosed in Fig. 4, which returns to the receiving element, has a wide multiplicity of interfering paths, tending to reduce the subsidiary reflections and thus render it improbable that a sufficient number of subsidiary reflections will be received by the receiving element to offer any obscuring effect on the reflections received from the defect. The form assumed by the intermediate element 16' in Fig. 1 is that of a wavy or corrugated surface which will entail an infinite number of different reflecting angles so that the subsidiary reflections will be dispersed.

In Fig. 2 the intermediate element 16'' has its sides formed in saw-toothed arrangement to provide a multiplicity of reflecting surfaces whose angle of inclination is such as to direct subsidiary reflections away from the surface 12 of the part 10.

In Fig. 3 still another form of intermediate member 16''' is disclosed wherein the member is formed with a zigzag contour to provide a multiplicity of reflecting faces of different angular positioning. The result in all of these forms is the same, namely, to disperse the subsidiary reflections instead of concentrating them in a beam which can obscure reflections from a defect.

The foregoing description of the invention is merely illustrative and changes may be made within the scope of the appended claims.

Having described our invention, what we claim and desire to secure by Letters Patent is:

1. In a system for testing material by supersonic waves, in which supersonic wave trains are transmitted from an electro-acoustic transducer toward said material and reflections of the wave trains are received by said transducer, characterized by means for increasing the time of travel of the wave trains between the transducer and the material, said means comprising an intermediate wave-conducting member for transmitting wave energy between the transducer and the material, said member having corrugated side walls to reflect at a plurality of angles those supersonic waves within the member which strike said walls, each of said corrugations having its linear dimensions greater than the wave length of said supersonic waves.

2. In a system for testing material by supersonic waves, in which supersonic wave trains are transmitted from an electro-acoustic transducer toward said material and reflections of the wave trains are received by said transducer, characterized by means for increasing the time of travel of the wave trains between the transducer and the material, said means comprising an intermediate wave-conducting member for transmitting wave energy between the transducer and the material, said member having saw-tooth side walls to reflect at a plurality of angles those supersonic waves within the member which strike said walls, each of said saw teeth having its linear dimensions greater than the wave length of said supersonic waves.

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