Sept. 2, 1958 J. J. CURRY ET AL 2,850,331

HANDLE CONNECTION FOR PERCUSSIVE TOOL

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Fig. 1.

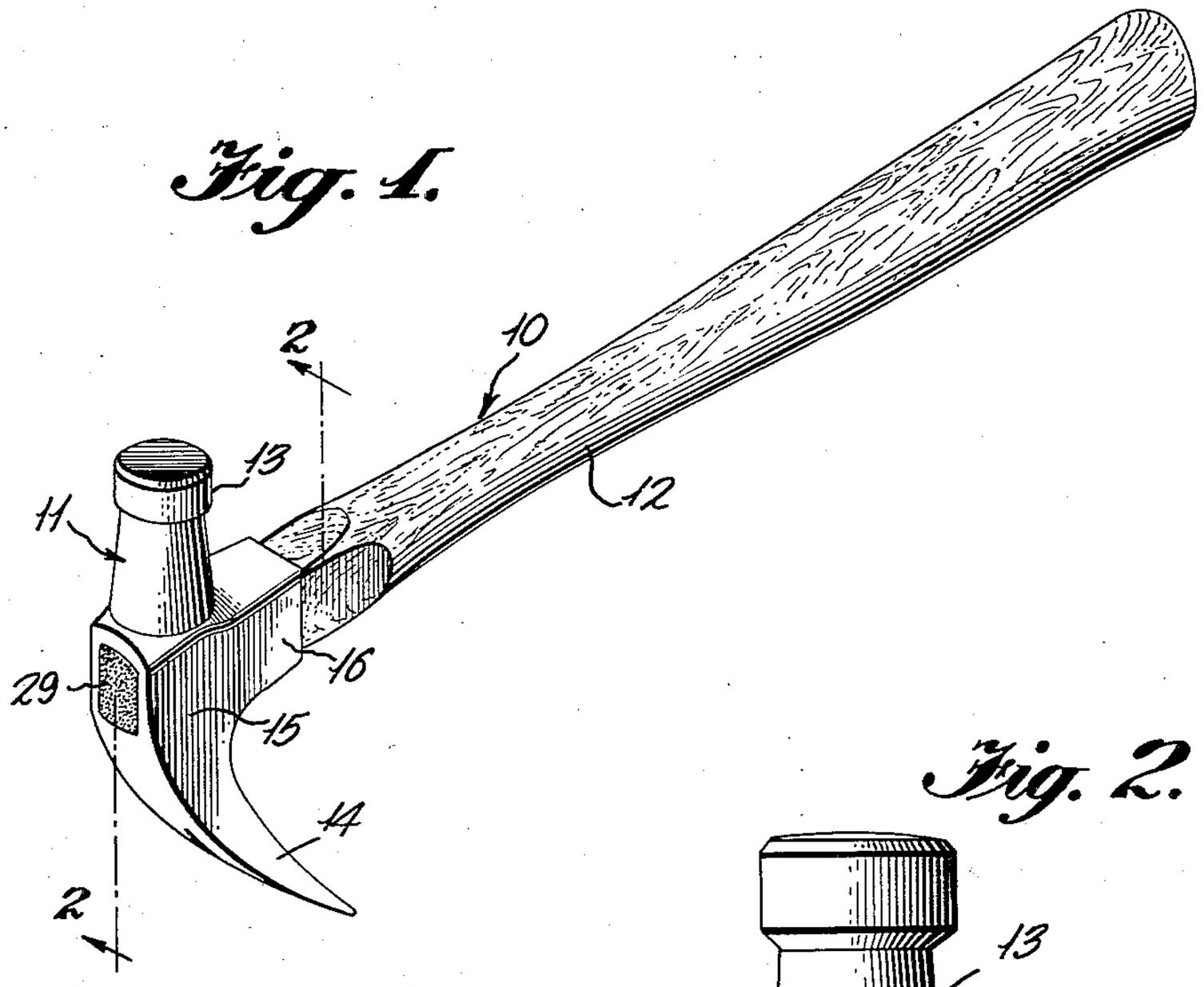


Fig. 2.

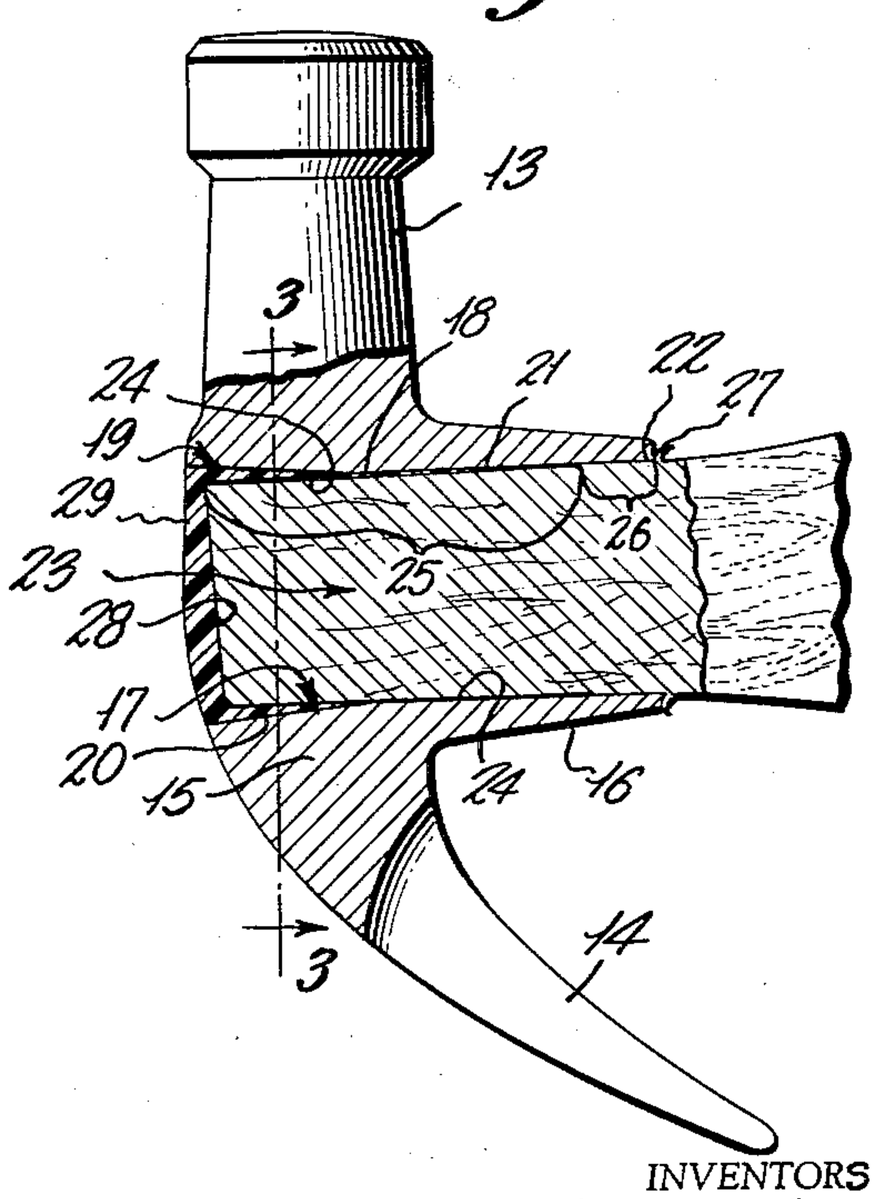
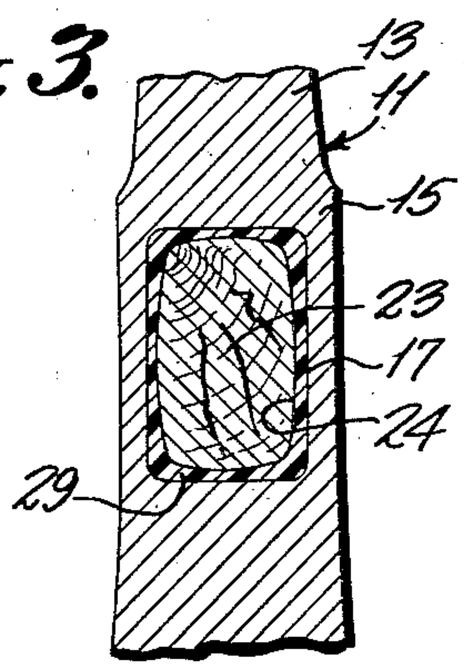


Fig. 3.



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HANDLE CONNECTION FOR PERCUSSIVE TOOL

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The present invention relates in general to hand tools, and more particularly to an improved means for attaching the heads to the handles of percussive tools, such as hammers, hatchets, axes and the like, in such a manner that the union will be strong and invariable during the normal useful life of the tool. The present invention may also have application to tools which, although not primarily percussive, involve occasional large stresses in the region of the junction between the handle and metal components of the tool, such as shovels, hoes, rakes, and the like.

Traditionally, handles of percussive and like tools have been secured in position in the eye or handle recess of the tool head or working part by providing a diverging or outwardly tapering region adjacent the exit end of the eye and driving one or a plurality of wedges into the end of the handle so as to expand the same into the diverging eye portion and prevent withdrawal of the handle. Such traditional fastening means have long been known to be inadequate. Such a fastening expedient involves as an inherent incident thereto damage to the handle which adversely affects many of the physical properties which are desired to be retained. Further, the wedges that are driven into the end of the wooden handle to force it into contact with the metal working head tend to work loose, due most frequently to changes in humidity which cause alternate swelling and contraction of the wood with a gradual decrease in tightness. Additionally, these wedge-fastening techniques present certain difficulties in maintaining uniform quality standards in mass production manufacture of such percussive tools. The wedges are generally driven into the handle ends by hand, and long experience in manufacturing such tools has indicated that the quality of the fastenings produced by such manual methods is noticeably impaired during the last several hours of each working day due to the tiring of the manual laborers.

The physical property of the wooden handles in such tools which is most adversely affected by the wedge-securing technique is the horizontal or longitudinal shear resistance of the handle. It should be noted that in percussive tools, the handle is under a cantilever beam-type of loading in which, in the case of a hammer for example, the half of the eye section of the handle adjacent the poll and bell of the hammer is under tension during impact and the half disposed adjacent the claws is under compression. When wedges which are usually disposed along both the vertical and transverse axes of the handle have been driven into the eye section, the fibres are split along the longitudinal medial axis of the handle, generally at the neutral axis thereof, creating a fissure which severely reduces the horizontal or longitudinal shear strength of the handle. Without the wedges, the interfibre bond so intercouples the tension and compression portions of the handle disposed oppositely from the neutral axis to provide relatively much greater longitudinal shear resistance.

Many expedients have been employed in an attempt to overcome these faults. They have included the provision of metal sleeves to hold the tool handle in place, the use of adjustable wedges which must be periodically driven by the owner of the tool to compensate for loosening of the joint, the use of metal handles, the casting of wedges in position in the tool, and the provision of rubber sleeves interposed between the handle and the head. None of these aforementioned expedients have proven to be entirely satisfactory.

The last-named expedient, that of providing cushioning material in the form of a sleeve entirely surrounding the portion of the handle projecting into the tool head eye, while originally considered to an effective solution to this problem, has been found on careful examination to have some rather serious defects. Perhaps the most critical of these is that the resilient sleeve tends to isolate from the handle the vibrations set up in the tool head during impact. This isolation of the tool head vibrations in the case of hammers is so significant that the handle exerts no significant dampening effect on the tool head vibrations and the head tends to resonate, setting up a tuning fork effect in the claws which causes the claws to fracture. Additionally, since the tool head eye is spaced throughout from the handle surface, it would be extremely difficult to maintain proper alignment between the handle and the tool head. Careful theoretical study of this assembly also reveals that it would be extremely difficult to achieve satisfactory curing of the sleeve when poured in position between the tool head and the handle, since the annular regions between the handle and the eye adjacent both ends of the handle are open to permit free flow of the sleeve material from the eye, and there would not be sufficient back pressure to produce the desired pressure for proper curing.

The use of metal handles was found to be unsatisfactory because the center of gravity of the tool is shifted downwardly along the handle a much greater distance from the head than with wooden handles, and the highly beneficial elasticity and stress absorption characteristics of wood are lost.

Adjustable wedges are effective for only a short time after initial assembly of the tool because the hygroscopic wood tends to swell when picking up moisture as a result of high ambient humidity conditions. As the wood swells within the fixed volume of the tool head eye, the wood cells, which may be likened to minute ping pong balls, are collapsed as required to adjust for the increased volume of the handle due to the swelling of the wood. Subsequently, when the relative ambient humidity has reduced below that of the wood in the eye, the wood when giving up moisture will have a tendency to reduce in volume, with the result that a loosening of the assembly is effected.

An object of the present invention, therefore, is the provision of a novel means for securing the heads to the handles of percussive tools which avoids the above-mentioned disadvantages.

Another object of the present invention is the provision of a novel means for securing handles to the heads of percussive tools which minimizes tendencies to loosen the handle in the eye due to external humidity variation.

Another object of the present invention is the provision of novel means for attaching handles to the heads of percussive tools, wherein physical damage to the wooden handle during assembly of the tool is minimized.

Another object of the present invention is the provision of novel means for securing handles to the heads of percussive tools involving the use of plastic resin adhesive compositions which are highly stable through the normally encountered variations in moisture or temperature, which effectively tolerate the shear and impact stresses to

which the tool is subjected and which effectively transmit the vibrations from the tool head to the handle to attenuate resonant vibrations in the head.

Another object of the present invention is the provision of novel means for securing handles to tool heads of percussive tools involving the use of adhesive compositions suitable to be poured or injected into cavities formed therefor by the handle and tool head eye, thereby alleviating the necessity of manually forcing wedges or the like into the handle.

Other objects, advantages and capabilities of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawing, illustrating one preferred embodiment of the invention.

In the drawing:

Figure 1 is a perspective view of a hammer, wherein the hammer head and handle are united in accordance with the present invention.

Figure 2 is a fragmentary longitudinal section view taken along the lines **2—2** of Figure 1; and

Figure 3 is a fragmentary transverse section view taken along the lines **3—3** of Figure 2.

Referring to the drawing, wherein like reference characters designate corresponding parts throughout the several figures, there is illustrated a claw hammer, generally indicated by the reference character **10**, which is especially constructed to facilitate the incorporation of certain plastic resin adhesive compositions, to be hereinafter described, as the bonding medium between the head **11** and handle **12** of the claw hammer. The hammer head **11** employed in the present invention is provided with the usual poll and bell **13**, bifurcated claws **14**, and central portion **15** having a downwardly projecting boss **16**. Extending along an axis perpendicular to the medial axis of the poll and bell **13** and through the central portion **15** and boss **16** is the usual eye **17**, the walls of which diverge slightly to the exit end **19** of the eye from a breaking point **18** lying approximately ⅝ to ½ inch from the exit end **19**, producing a diverging surface region **20** which sweeps back approximately 1/32 of an inch along its total extent relative to the projected plane of the remaining surface region **21** of the eye extending from the breaking point **18** to the entrance end **22** of the eye. This is the conventional hammer head construction normally used in connection with the wedge-type of securing technique for hammers and other percussive tools.

The portion **23** of the handle **12** which is designed to be fitted into the eye **17** of the head **11** is modified in design to adapt the hammer to receive a plastic resin adhesive compound for bonding the handle to the hammer head. To this end, the lateral faces **24** of the substantially rectangular cross section portion **23** of the handle designed to be projected into the eye **17** are shaped in the usual way so that handle surface portions in the region **25** extending from the outer end thereof to approximately ¼ inch from the entrance end **22** of the eye are spaced slightly from the coextensive adjacent surfaces of the eye **17**. The remaining surface portions in the region **26** of the eye section **23** of the handle diverge slightly from the point approximately ¼ inch inside the eye to a greater cross section than that of the entrance end **22** of the eye and is in intimate frictional engagement throughout with the eye surface region **21** when the handle eye section **23** is forcibly driven to its full extent within the eye. In accordance with conventional practice, the handle **12** is driven into the eye **17** of the head **11** to a point where the entrance end **22** of the eye **17** begins to peel back the wood, the burrs **27** formed at the entrance **22** thereby forming a seal which extends entirely around the junction between the entrance of the eye **17** and the handle **12**.

As is illustrated in Figure 2, the eye section **23** of the handle is cut to a length and in a plane parallel to the plane through the front and rear edges of the exit end of the eye that when the sealing burr **27** and shoulder formed at the entrance **22** of the eye is sufficient to substantially prevent further admission of the handle into the eye **17**, the end **28** of the handle eye portion **23** terminates approximately ⅛ to ¼ of an inch inwardly of the exit end **19** of the eye **17**. This construction forms, together with the unoccupied space between the adjacent surface regions **25** of the handle eye portion **23** and the complementary surface regions of the eye **17**, a cup or cavity which opens through the exit end **19** of the eye and is sealed at and immediately inside of the entrance end **22** of the eye. Into this cavity is introduced a plastic resin adhesive composition, indicated at **29**, which, when cured, forms a substantially permanent bond between the eye portion **23** of the handle and the eye **17** of the hammer head **11** which resists any loosening of the handle in the hammer head and retards adverse action of humidity variation on the eye portion of the handle.

The basic resin component of the plastic resin adhesive composition employed in accordance with the present invention for bonding the handle **12** and head **11** of the hammer is drawn from the epoxy resin family. Epoxy resins are based on ethylene oxide or its homologs or derivatives and are characterized by a chain molecule which has an epoxy group at each end. Typical of these, and the epoxy resin which is employed in the preferred embodiment of the present invention, is the compound made by condensation of epichlorohydrin (1-chloro - 2,3 - epoxypropane) and bisphenol A (2,2-p-hydroxyphenylpropane) reacted at about 100° C. in the presence of sodium hydroxide. The epichlorohydrin is a coproduct obtained during the process of producing glycerol from petroleum. In producing the epoxy resin, the epichlorohydrin is reacted with bisphenol in an average proportion of 0.8 lb. of bisphenol to 0.4 lb. epichlorohydrin to obtain one pound of epoxy resin.

This compound, which will be hereinafter termed epichlorohydrin bisphenol, is a commercially available compound, and is prepared into a production mixture for use in one preferred embodiment of the present invention by mixing 91 grams of black dye with 40 pounds of the epichlorohydrin bisphenol. It is understood, however, that other tinting additives may be used, or that the commercially obtainable epichlorohydrin bisphenol unmixed with other compounds may be used, without in any way altering the effectiveness of the adhesive.

A special promoter and modifier mixture to be added to the mixture of epichlorohydrin bisphenol and black dye in the preferred embodiment is formed of an amine promoter such as triethylene tetramine and a synthetic rubber modifier such as Thiokol liquid polymer, a condensation polymer of ethylene dichloride and a polysulfide such as sodium tetrasulfide, whose average structure may be represented by:

$$HS\text{-}(C_2H_4\text{-}O\text{-}CH_2\text{-}O\text{-}C_2H_4\text{-}S\text{-}S)_6\text{-}C_2H_4\text{-}O\text{-}CH_2\text{-}O\text{-}C_2H_4\text{-}SH$$

An example of this promoter and modifier mixture is formed of 34.5 pounds of Thiokol and 5.5 pounds of triethylene tetramine mixed together to produce 40-pound lots of the mixture.

The final adhesive mixture to be applied to the hammer head and handle is blended immediately prior to addition to the hammer by mixing, as an example, 16.8 grams or 42% of the promoter and modifier mixture formed of Thiokol and triethylene tetramine and 23.2 grams or 58% of the above-mentioned production mixture consisting of epichlorohydrin bisphenol and black dye. Broken down into its various components, a 40-gram sample adhesive compound to be employed in the preferred embodiment of the present invention consists of 14.5 grams of the Thiokol modifier, 2.3 grams of the triethylene tetramine promoter, and 23.2 grams of the epoxy production mixture formed of 40 pounds of epichlorohydrin bisphenol and 91 grams of black dye.

In the practice of one preferred embodiment of the invention, the claw hammer heads **11** are preheated to approximately 200° F. in any conventional manner, as by placing them on an electric hot plate. The purpose of preheating the tool head is to increase the curing or hardening rate of the epoxy plastic resin, with the result that delays in production from excessive curing time are reduced. The hammer heads may be preheated either with the handles already driven into the eyes of the tool head or with the tool heads separate from the handles.

The hammer heads **11** with the handles **12** driven therein are then hung on racks in a vertical position to permit the epoxy adhesive composition, prepared in the manner described above, to be poured or injected into the upwardly opening cavity formed adjacent the upwardly facing exit end **19** of the tool head **17** and the bounding region between the facing portions of the handle and tool head eye in the surface regions **25** and **20**. The resin may be easily dispensed into this cavity by placing the resin in a plastic bottle onto which a ribbon top cap and spout are affixed so that the proper amount of plastic resin can be accurately admitted to the cavity in the tool head eye. Since polymerization of the adhesive compound begins to take place immediately when the promoter and resin are added together, and the average period before the compound begins to set to an undesirable degree is one-half hour, the production mixture of the epoxy resin and dye should not be mixed with the promoter mixture until immediately before filling of the cavity in the hammer head eye.

The poured tools are then allowed to remain on the racks for a period of time ranging from 4 hours to overnight, depending upon the temperature to which the tool heads have been preheated. It is to be understood that the preheating operation may be entirely eliminated if it is convenient to permit the tools to remain at rest for a curing period of the order of eighteen hours. Following the curing period, the tools are chipped, wiped, inspected, and are ready for shipment to customers. By the use of the epoxy technique of assembly, the employment of manual labor required for the many operations involved in conventional handle assembly techniques is eliminated completely.

Other amine accelerator catalysts which can be used with the Thiokol liquid polymer to form a modifier and promoter component to be added to the epoxy resin, instead of the triethylene tetramine mentioned above are: tri-dimethylaminomethylphenol or less active amines such as, in decreasing order of reactivity, diethylenetriamine, dimethylaminopropylamine, dimethylaminomethyl-phenol, benzyldimethylamine, piperidine, diethylamine, dimethylaminopropionitrile, and pyridine.

The incorporation of the Thiokol liquid polymer modifier, which is a synthetic rubber, to the epoxy formulation is for the purpose of increasing the cold temperature shock resistance of the compound to a satisfactory range. Without the Thiokol modifier, the checking resulting from cold temperature shocking when the cured assemblies were thermally shocked by exposing them alternately to heat and cold in the order of 0° F. to 80° F., while it had no adverse effect on the shear strength, did result in a considerable reduction in the resistance to impact. The formulation employing the Thiokol liquid polymer was found to be completely successful in overcoming these cold temperature deficiencies.

Exhaustive tests have indicated that in addition to having good resistance to cold temperature cracking resulting from differences in the linear coefficient of expansion between the wood, the cured epoxy resin, and the metal tool head, the hammer constructed in accordance with the present invention was found to have very good characteristics when subjected to cantilever loading, shear, impact, solubility, and moisture and high temperature dimensional stability tests. The epoxy resin composition **29**, when cured in the form of the downwardly facing cup defined by the associated surfaces of the handle eye portion **23** and eye **17**, produces a strong intimate bond between the head **11** and handle **12**, which possesses sufficient resilience to resist cracking under thermal shock. By this construction, vibrations are transmitted from the head to the handle to give the tool a proper "feel" and to prevent confining the vibrations to the hammer head where they will resonate and produce a tuning fork effect in the claws, causing untimely fracture of the claws. The addition of the black dye to the epoxy resin in the manner described above tints the resin to match the color of the tool head, thereby producing a neat and attractive tool, in addition to the advantages enumerated above.

It has been found to be advantageous in certain situations to add a solvent such as toluene and toluol in a pecentage of about 2 to 5% by weight of the epichlorohydrin bisphenol resin only prior to pouring or injecting the epoxy formulation into the hammer eye cavity. Such solvents reduce the viscosity of the epoxy formulation and therefore aid in wetting out the adjacent surfaces of the tool head and handle eye sections, thereby facilitating the pouring or injection of the epoxy mixture into the eye cavity.

While but one particular embodiment of the invention has been particularly shown and described, it is apparent that various modifications may be made in the invention without departing from the spirit and scope thereof, and it is desired, therefore, that only such limitations shall be placed thereon as are imposed by the prior art and are set forth in the appended claims.

We claim:

1. A percussive tool comprising a metallic head with a handle-receiving eye therethrough having entrance and exit ends, a handle having an end portion within the eye in pressure tight contact with the head over an area adjacent the entrance end of the eye and spaced from the head adjacent the exit end of the eye to provide a closed-bottom cavity open to the exit end of the eye and encircling the handle end portion, and a body of bonding material including epoxy resin filling the cavity whereby the head is bonded to the handle and the handle has intimate contact with the metallic head to dampen vibrations set up in the head by impact shock.

2. A percussive tool comprising a metallic head with a handle-receiving eye therethrough having entrance and exit ends, a handle having an end portion within the eye in pressure tight contact with the head over an area adjacent the entrance end of the eye and spaced from the head progressively increasing distances from the area of contact toward the exit end of the eye to provide a closed-bottom cavity having outwardly diverging walls and open to the exit end of the eye and encircling the handle end portion, and a body of bonding material including epoxy resin filling the cavity, whereby the head is bonded to the handle and the handle has intimate contact with the metallic head to dampen vibrations set up in the head by impact shock.

3. A percussive tool comprising a metallic head with a handle-receiving eye therethrough having entrance and exit ends, a handle having an end portion within the eye but terminating short of the face of the head at the exit end of the eye, the end portion being in pressure tight contact with the head over an area adjacent the entrance end of the eye and spaced from the head progressively increasing distances from the area of contact toward the exit end of the eye to provide a closed-bottom cavity having outwardly diverging walls and open to the exit end of the eye and encircling the end portion, and a body of bonding material including epoxy resin filling the handle-encircling cavity and the eye substantially flush with the face of the head at the exit end of the eye to form a cap of bonding material enclosing the outer end of the handle end portion and having a skirt of tapering

cross-section, whereby the head is bonded to the handle and the handle has intimate contact with the metallic head to dampen vibrations set up in the head by impact shock.

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