April 10, 1962 T. J. CARTER 3,028,755

APPARATUS FOR WATER PENETRATION TESTING OF SOLE LEATHER

Filed Nov. 4, 1959 2 Sheets-Sheet 1

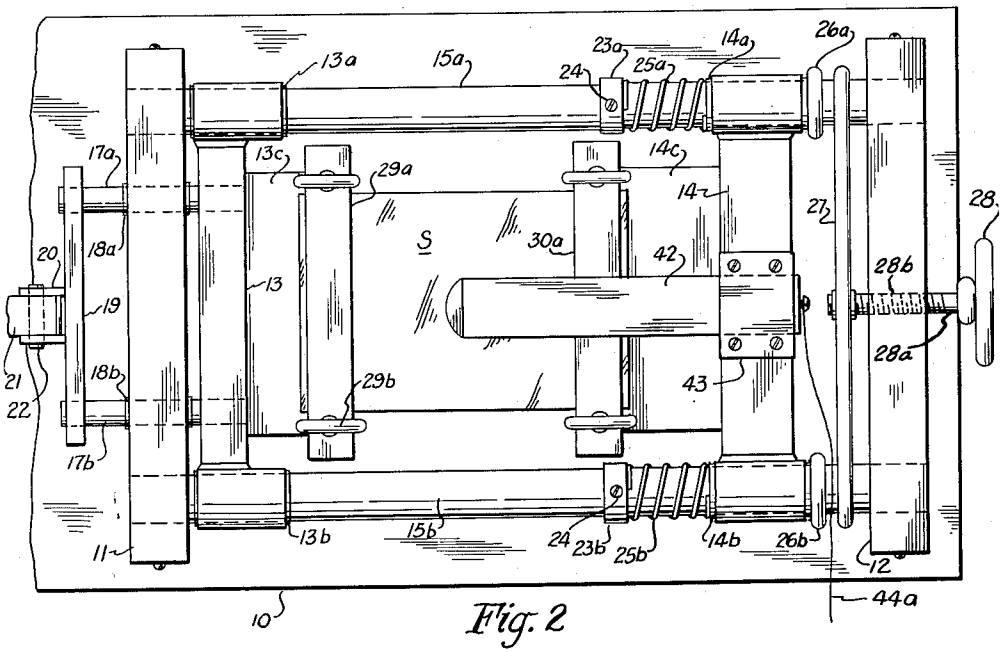


Fig. 2

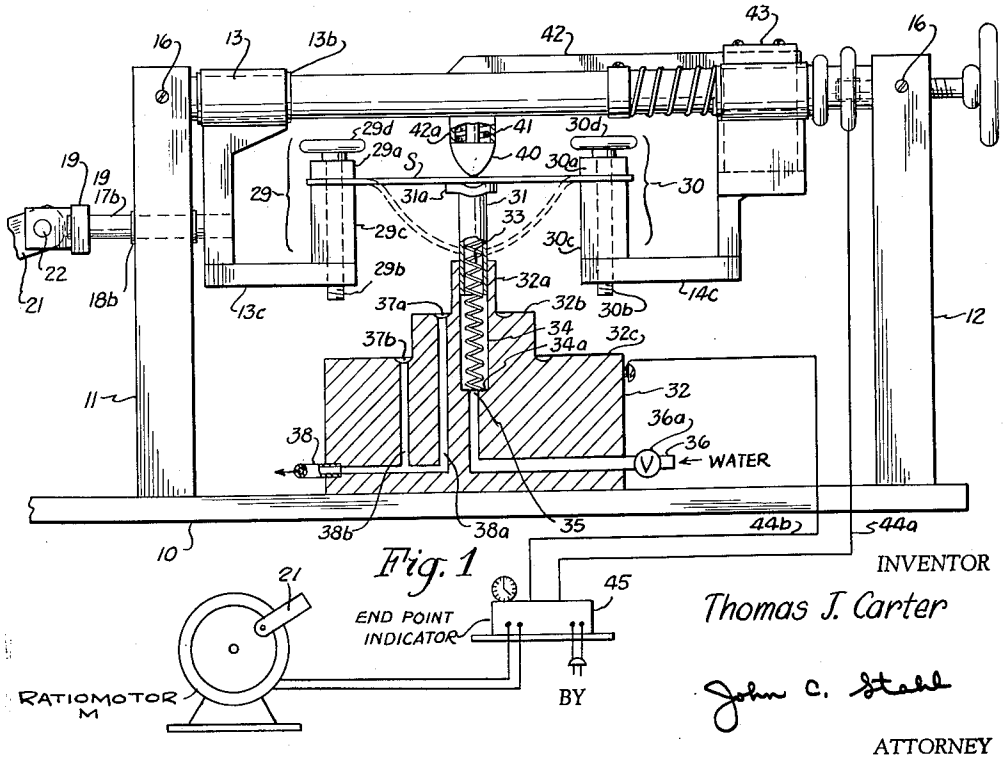


Fig. 1

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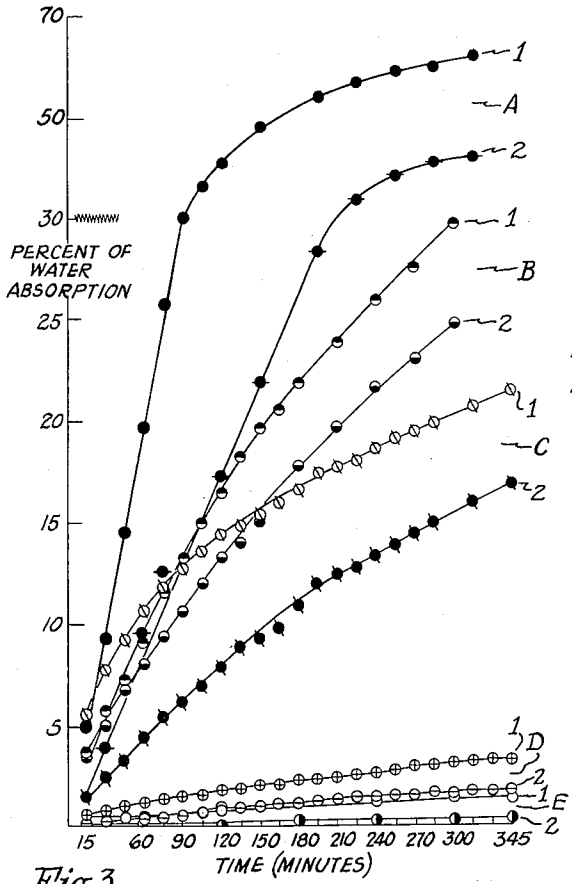


Fig. 3

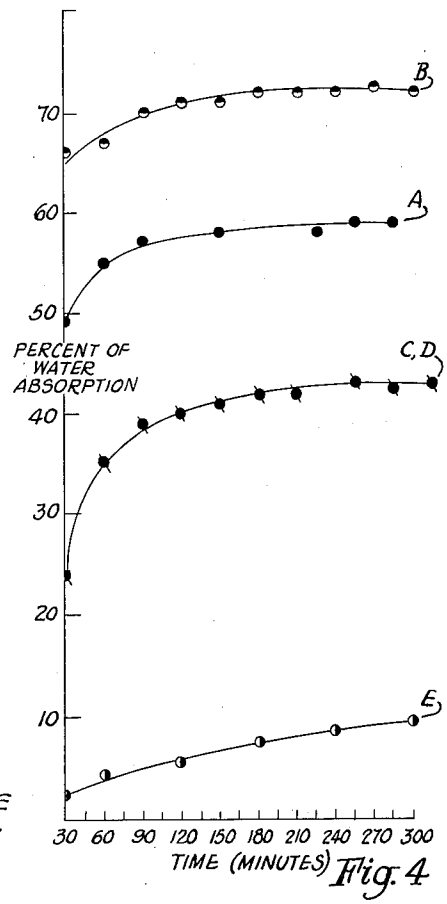


Fig. 4

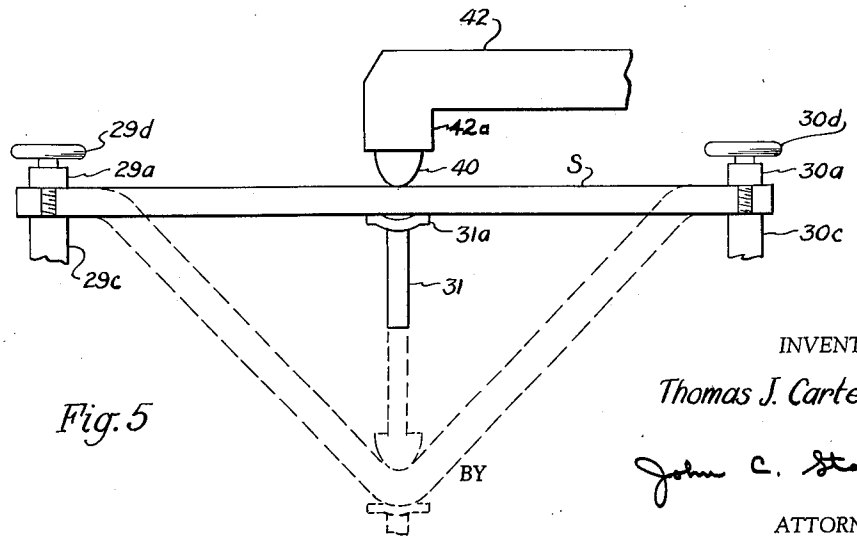


Fig. 5

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APPARATUS FOR WATER PENETRATION TESTING OF SOLE LEATHER

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6 Claims. (Cl. 73—100)

This invention relates to apparatus for testing the water penetration of leather and other flexible materials and more particularly to apparatus for determining the resistance of sole leather to water penetration under dynamic conditions.

The flexural properties of leather and its ability to transmit water vapor make it a highly desirable material for the construction of shoes. However, its porosity causes weak resistance to water penetration and treatments must be applied to leather to improve its water resistive properties.

A number of test methods have been used to determine the water resistance of leather. These methods, however, do not give a reliable measure of the water resistance of leather under conditions of use. For example, not only does flexing increase the rate of water penetration but also the pentration is related to the angle to which a specimen is bent in flexing.

The subject invention contemplates apparatus whereby the water resistance of sole leather is measured under simulated conditions of practical wear and wherein the various factors which influence the rate of water penetration are encountered. Specifically, the apparatus consists of reciprocating members for flexing the specimen, means for applying water to and abraiding the underside of the specimen and an electronic device to indicate the end point of the test. The resistance to penetration is measured by the number of flexes and/or the time required for penetration. The influence of flexing, thickness of the specimen, location on the leather bend and compression of the specimen upon water penetration and water absorption are determined. In general, the specimen is clamped so that the angle of bend is approximately 90°. For leather specimens having a high resistance to grain cracking, however, adjustment can be made to decrease the angle of the bend and thereby increase the rate of water penetration.

The primary object of this invention is to simulate conditions encountered by the sole of a shoe in actual service.

Another object of this invention is to provide a flexing mechanism which will bend a leather specimen in contact with water at an angle similar to that of a shoe in actual service.

Still another object of this invention is to provide means for determining the resistance of sole leather to penetration by water.

Another object of this invention is to provide means whereby the water resisting effects of various impregnating materials applied to sole leather may be evaluated.

A further object of this invention is to provide means whereby a sole leather specimen may be flexed at various angles of bend.

Other uses and advantages of the invention will become apparent upon reference to the specification and drawings in which:

FIG. 1 is a side elevational view of the water penetration testing apparatus of this invention;

FIG. 2 is a top plan view of the apparatus of FIG. 1;

FIG. 3 is a graph illustrating the percentage of water absorption for flexed and unflexed leather specimens plotted as the ordinate and the time required for water penetration as the abscissa;

FIG. 4 is a graph showing the percentage of water absorption plotted against the time required for penetration wherein portions of the specimens of FIG. 3 are exposed to standard penetration test procedures; and

FIG. 5 is an enlarged diagrammatical view showing the specimen of FIG. 1 in both flexed and unflexed positions.

Referring to the drawings, there is shown in FIGS. 1 and 2 a base **10** to which end panels **11** and **12**, respectively, are welded or otherwise secured. The base **10** and panels **11—12** are suitably constructed of steel plate or the like. The outboard ends of a pair of spaced parallel tracks **15***a*—**15***b* pass through bores in end panels **11** and **12** and are detachably secured thereto by screws **16** which pass through recesses in the side panel portions as best seen in FIG. 1 of the drawings. In a preferred embodiment of the invention, the tracks **15***a*—**15***b* are spaced approximately 7 inches apart whereas end panels **11—12** are approximately 14 inches apart.

Assemblies **13—14**, to which a test specimen is secured in a manner hereinafter to be discussed in detail, are slidably mounted on tracks **15***a*—**15***b*. A pair of cylindrical bearings **13***a*—**13***b*, such as are well known in the art, are integrally mounted within the upper portions of the assembly **13**; in like manner, bearings **14***a*—**14***b* mount within the upper portions of the assembly **14**. The track **15***a* is journaled in the bearings **13***a*—**14***a*, likewise, track **15***b* is journaled in bearings **13***b*—**14***b*.

The assembly **13** is reciprocally driven by a ratiomotor M which is preferably geared to operate at 30 cycles a minute. Assembly **14** is actuated by the specimen only to the extent necessary to control tension on the specimen upon extending.

As best seen in FIG. 2 of the drawings, the inboard ends of a pair of connecting rods **17***a*—**17***b* pass through apertures in the assembly **13** and attach thereto in a conventional manner. The rods **17***a*—**17***b* are journaled in cylindrical bearings **18***a*—**18***b*, respectively, fixedly mounted in the mid-portion of end panel **11**. A cross head **19** (see FIG. 2) of a swivel bracket **20** is adapted to receive the outboard ends of rods **17***a*—**17***b* in a conventional manner. The ratiomotor M heretofore referred to connects with bracket **20** by a shaft **21** and a pin **22**, respectively.

Referring again to FIGS. 1 and 2 of the drawings, collars **23***a*—**23***b*, or the like, are detachably secured to the tracks **15***a*—**15***b*, respectively, as by set screws **24**. Compression springs **25***a*—**25***b* are concentric about tracks **15***a*—**15***b*, the outboard ends of the springs **25***a*—**25***b* abut the inboard portions of the assembly **14** while the inboard ends of said springs abut the collars **23***a*—**23***b*. The position of collars **23***a*—**23***b* are adjusted to regulate the tension on the assembly **14** through the action of springs **25***a*—**25***b*. Leather washers **26***a*—**26***b* positioned on the tracks **15***a*—**15***b*, respectively, abut the outboard ends of the assembly **14** and absorb shock between the assembly **14** and a spacer bar **27** which slidably mounts on the tracks **15***a*—**15***b*.

The inboard end of a spindle **28***a* passes through an aperture in bar **27** and connects thereto in a conventional manner. Spindle **28***a* passes through a bushing **28***b* incorporated in the end panel **12** and terminates in a knob **28**. Application of a torque to the knob **28** controls the displacement of the assembly **14**. In a preferred embodiment of the invention, the maximum displacement of the assembly **13** is approximately 1.5 inches whereas that of assembly **14** varies within the limits of 0.0 to 0.5 inch.

As best seen in FIG. 1 of the drawings, clamp assemblies **29—30** are removably mounted on horizontal extensions **13***c*—**14***c*, respectively, of the assemblies **13—14**. The extensions **13***c*—**14***c* are integral with the lower por-

tion of the respective assemblies 13—14. The outboard ends of a noncorrosive metallic strip 29*a* of the assembly 29 are drilled to clear bolts 29*b* which screwably insert into the extension 13*c*. A rectangular spacer 29*c* corresponding to the shape of the strip 29*a* is also drilled to pass the bolts 29*b*. Wing nuts 29*d*, or the like, attach to the upper portions of the bolts 29*b* to secure one end of the specimen S between the strip 29*a* and the spacer 29*c*, respectively. Likewise, the other end of the specimen S is secured between strip 30*a* and spacer 30*c* by wing nuts 30*d* or the like placed on bolts 30*b*, respectively.

A wetting device, best seen in FIG. 1 of the drawings, consists of a cylindrical pump-type plunger 31 suspended vertically in a water container 32. A circular perforated plate 31*a*, integral with the side wall portions of plunger 31, is made resilient by spring 33. Plate 31*a* maintains contact with the specimen S at every stage of the cycle. The plate 31*a* is preferably countersunk at the center (see FIGS. 1 and 5) to retain water momentarily, and is bevelled at the edge to prevent too severe scuffing of the specimen.

The plunger 31 slidably inserts into a recess 34 in the neck 32*a* of container 32. An orifice 35 in the lower surface 34*a* of recess 34 admits water at the rate of approximately 450 to 500 ml. per hour, said flow is controlled by a valve 36*a* in the inlet pipe 36. On bending, as shown in the broken line portions of FIGS. 1 and 5 of the drawings, the specimen S forces the plunger 31 downward into the recess 34 against the force of spring 33 which abuts the surface 34*a*. A pumping action results from this reciprocal motion. Water entering through the open bottom portion of the plunger 31 is forced up and through the perforations in the plate 31*a* producing a spray on the under surface of the specimen, the water being forced out in spurts rather than as a continuous flow. As a result of the constant contact of the plate 31*a* with the lower surface of the specimen S, the plate 31*a* serves as a mild abrader as well as a terminal in the electrical circuit hereinafter to be described. The plunger 31 tends to rotate to a certain degree as the specimen is unbent in the cycle, thereby giving an abrasive effect that simulates conditions to which the sole of a shoe is subjected when worn.

In a preferred embodiment of the invention, and as best seen in FIG. 1 of the drawings, the container 32 is of stepped configuration. Channels 37*a*—37*b* provided on the surfaces 32*b*—32*c* of container 32 conduct the unused water by way of conduits 38*a*—38*b* to an outlet conduit 38. The lower terminal of the electronic device hereinafter to be described may be conveniently attached to the container 32 or inserted into the recess 34, respectively, in a conventional manner.

The top terminal of the electronic device (see FIG. 1) consists of a spring-loaded presser foot 40, rectangular in shape, with its bottom surface curved to conform with the crease in the bent specimen (see FIG. 5). The presser foot 40 slidably inserts in an extension 42*a* of housing 42. Said foot 40 maintains contact with the top (dry) surface of the specimen S at every stage of the flexing cycle by the action of the spring 41 extending between presser foot 40 and the top, inside portion of the housing 42. The outboard end of the housing 42 is fixedly secured to the assembly 14 by a pillow block 43 of insulating material such a Lucite or the like, as best seen in FIG. 2 of the drawings. In a preferred embodiment of the invention, the housing 42 is of hollow tubular form and constructed of an electrical conducting material. An electrical lead 44*a* connects to the housing 42 in a conventional manner.

The foot 40 tends to revolve to-and-fro at an angle of about 15° within housing extension 42*a* as the specimen is unbent. This movement is important because water may penetrate the specimen in an area outside of the crease as well as in the center of the crease and the limited rotation of the presser foot permits the detection of the end point over such an area. Penetration points are found to occur over a greater area for untreated specimens than for treated specimens as hereinafter to be described.

As diagrammatically illustrated in FIG. 1 of the drawings, leads 44*a*—44*b* connect with an end point indicator 45 such as is well known to the art. As heretofore described one terminal of the lead 44*a* attaches to the presser foot 40 through housing 42, the other terminal of said lead 44*a* connects with the end point indicator 45. Lead 44*b* connects plunger 31 with the indicator 45. When water penetration of the specimen undergoing evaluation occurs, the external electrical circuit is completed thereby energizing a control circuit within indicator 45 to cut off the referred-to ratiomotor. The indicator 45 also includes an electrical timer whereby time is recorded for both the beginning and termintaion of the testing process.

FIG. 5 of the drawings diagrammatically illustrates a leather specimen S in both the unflexed and the flexed positions, wherein the flexed position is represented by broken line portions. It will be observed from FIG. 1 of the drawings that the specimen is flexed so that the crease is perpendicular to the longitudinal axis of the apparatus and the convex surface is below the plane of the applied force. The original shape of the specimen is not fully restored when the assemblies 13—14 return to their original positions due to the stiffness of the leather and to the pressure applied by the presser foot 40.

Specimens used for the water penetration tests on the apparatus of FIG. 1 were 3 by 6 inches, however, specimens having various widths or a half sole of conventional width can be tested on the device. Sizes under 2½ inches in width are unsatisfactory, however, because water frequently escapes around the edges and makes contact with the top terminal of the indicator 45, especially when the resistance of the specimen to penetration is very great.

To clamp the specimen to the apparatus, the assemblies 13—14 are set about 4½ inches apart, therefore the specimen S should have a minimum length of 6 inches to assure proper clamping. A separation of 4½ inches between the assemblies 13—14 produces an angle of bend of approximately 90°. It is understood, of course, that the distance between the assemblies 13 and 14 may be varied to produce the desired angle of bend. Also, it is often necessary to adjust said assemblies to compensate for the thickness and stiffness of the specimen.

Commercial sole leather was used to obtain the data illustrated in FIGS. 3 and 4 of the drawings. A group of specimens, prepared at the National Bureau of Standards Leather Laboratory, includes untreated vegetable-tanned crust, impregnated crust and regular finished sole leather. Specifically, as illustrated in FIGS. 3 and 4 of the drawings, untreated chrome-retanned crust leather is designated by the reference letter A, untreated vegetable-tanned crust leather by B, C designates the flesh side of untreated vegetable-tanned finish leather, D represents the grain side of said untreated vegetable-tanned finish leather and G designates treated (impregnated) vegetable-tanned crust leather. The specimen E was prepared with an Oronite treatment, Oronite being a trade name for a blend of a group of low molecular weight polybutenes obtained from the Oronite Chemical Company. The numerals 1 and 2 in FIG. 3 of the drawings designate the flexed and unflexed specimens, respectively. The specimens C, D, E, and G, as illustrated in FIG. 4, were cut from untested parts of the corresponding specimens in FIG. 3 and submitted to a static water penetration testing procedure hereafter to be described. Prior to testing, the specimens utilized to obtain the data shown in FIGS. 3 and 4 were conditioned in an atmosphere of 72° F. and 50% relative humidity.

In FIG. 3 of the drawings, the percentage of water absorbed by the flexed and unflexed specimens A, B, C, D, and E is plotted against the time of exposure in minutes.

The results show the influence of flexing by the increase in the amount of water absorbed during flexing in comparison with that absorbed by the unflexed specimens. It will be noted that the rate of absorption is fairly steady for each type of leather. The chrome-retanned leather absorbs the greatest amount of water and shows a tendency to reach equilibrium at a greater rate than the other types of leather. Furthermore, improvement due to impregnation can be seen in comparing the results for the treated leather with the untreated leather. The flesh side of the untreated vegetable-tanned finished leather is intermediate and absorbs a greater amount of water than the grain side, the more porous sponge-like form of the flesh side being responsible for the lower resistance to water.

The curves illustrated in FIG. 4 are typical water absorption curves for leather tested by the standard immersion method described in Federal Specification KK–L–311*a*. The results indicate that the rate of water absorption for specimens immersed in water is greatest during the first 30 minutes of exposure in comparison to the steady rate of absorption shown by the results of FIG. 3.

The resistance to water peneration under dynamic and static conditions is given in the following tabulation:

TABLE I

Resistance to Water Penetration Under Dynamic and Static Conditions

Type of Leather	No. min. before penetration of specimen		Water absorbed at time of penetration, mg/min.	
	flexed	unflexed	flexed	unflexed
Untreated veg.-tanned crust	6	11	550.0	263.6
Untreated chrome-retanned crust	9	21	344.4	200.0
Untreated veg.-tanned finished (grain side)	210	960+	10.9	11.4
Untreated veg.-tanned finished (flesh side)	106	305	12.6	52.1
Treated (impregnated veg.-tanned crust)	345	1680+	3.4	0.7

It is evident upon inspection of the results of Table I that flexing increases the rate of penetration and the rate of absorption. Flexing the leather causes a pumping action, heretofore described, which is partially responsible for the rapid penetration rate. During the testing procedure it was observed that the water appears to enter the voids of the leather as the specimen is bent and is forced through the voids as the specimen is unbent. Penetration is generally detected during the return of the reciprocating assembly **13** to its original position. The results of Table I also amplify the findings illustrated in FIGS. 3 and 4 of the drawings.

Other test results indicate that the logarithm of the number of flexes to penetration is a direct function of the thickness of the leather. Also, the rate of water penetration and water absorption depends upon the location of the specimen on the leather bend.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of invention as defined in the appended claims.

What is claimed is:

1. A device for testing the resistance of a test specimen to liquid penetration comprising a base, panel members mounted on said base, track means connecting said panel members, a test specimen, first and second clamp means slidably mounted on said track means and securing said test specimen, drive means for reciprocally moving said first clamp means and thereby flexing said test specimen, a liquid container, and pump means adjacent one side of said test specimen for directing liquid from said container against said one side of said test specimen, said pump means being actuated by flexure of said test specimen thereagainst whereby said test specimen is simultaneously wetted and abraded by said pump means.

2. The invention of claim 1 including means to indicate the liquid penetration of said specimen.

3. The invention of claim 1 including an endpoint indicator, an electrical circuit connecting with said indicator and including electrodes attached to the opposite sides of said test specimen, said electrical circuit being completed through the liquid penetrating said test specimen.

4. The invention of claim 2 including means to deactivate said drive means and record the time of the liquid penetration of said specimen.

5. A device for testing the water penetration of a sole leather specimen comprising a base, first and second panel members mounted on said base, track means connecting said first and second panel members, first and second specimen clamping means slidably mounting on said track means, said first clamping means being reciprocally driven by a ratiomotor, a water bath, a spring biased plunger adjacent said leather specimen, means for directing water from said bath against said test specimen and means to deactivate said ratiomotor upon water penetration of said leather specimen.

6. Apparatus for testing the water penetration of sole leather comprising a base, first and second end panels connecting to said base, first and second track members connecting said first and second end panels, first and second clamp means for securing said sole leather, said first and second clamp means slidably mounted on said first and second track members, said first clamp means positioned in proximity to said first end panel and said second clamp means positioned adjacent said second end panel, drive means to reciprocally move said first clamp means, means to adjustably position said second clamp means, a liquid container, spring biased plunger means adjacent the lower surface of said sole leather specimen, means for directing water against said specimen and electrical means to indicate the water penetration of said specimen.

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