STABILIZED WOOD GUNSTOCKS IN MARINE CORPS MARKSMANSHIP COMPETITION

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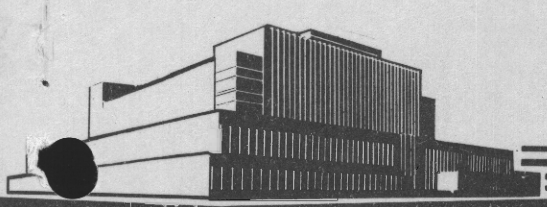

FOREST PRODUCTS LABORATORY
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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

Foreword

The data on stabilized gunstocks presented in this report were obtained from a program of research, testing, and evaluation conducted jointly by the U.S. Marine Corps and the Forest Products Laboratory.

The Crane Creek Gun Stock Company, Waseca, Minn., provided most of the rifle stocks used in these experiments; polyethylene glycol was supplied by the Dow Chemical Company, Midland, Mich.; Reinhart Fajen, Inc., Warsaw, Mo., shaped and inlet the first experimental target stocks made from glycol-stabilized laminated blanks; and the Koppers Co., Pittsburgh, Pa., provided experimental material stabilized by the acetylation and impreg processes. The contributions of these industry cooperators are hereby gratefully acknowledged.

The primary objective of the research here reported was to utilize modern technological developments, methods, and processes to produce a superior rifle stock that would meet the most exacting performance requirements for military and civilian use. Other objectives were to cut production time and reduce costs, two factors that could be decisive in military procurement as well as in long-range competition with substitute materials.

STABILIZED WOOD GUNSTOCKS IN MARINE CORPS MARKSMANSHIP COMPETITION

By

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The gunstock of the future is here--a wood stock that will not shrink, warp, or swell under conditions ranging from the Mojave desert to outright soaking in water. Woods of many kinds that have not been suitable in the past for gunstocks can be used, and the old reliable stock woods have been improved to the point where special bedding devices can be discarded.

That, in a nutshell, is what has been found to date in use tests by the Marine Corps of new types of chemically treated wood gunstocks developed at the U.S. Forest Products Laboratory, a federal institution maintained at Madison, Wis., by the Forest Service of the U.S. Department of Agriculture. The use testing began about 2 years ago and included the most rigorous prooftesting of all--competition in marksmanship matches.

The performance of these stocks was so outstandingly superior to that of untreated stocks that the authors are convinced no civilian, military-combat soldier, competitor, target-shooter, or hunter can afford to use anything else.

Humidity Affects Accuracy

Every experienced hunter or target-shooter has been plagued with a rifle that will not maintain its zero from one season to the next. Sometimes it fails to maintain zero from sighting-in for a hunting trip to time of arrival at the hunting area. Consequently, the nagging question persists: "Is my rifle still sighted-in for that all-important first shot?"

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[2] Maintained at Madison, Wis., by the Forest Service, U.S. Department of Agriculture, in cooperation with the University of Wisconsin.

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He can check his sights to see that they are set and securely in place, but he cannot determine what has happened to the stock. Has it swelled, shrunk, or warped with results disastrous for shooting accuracy?

Throughout the history of rifle marksmanship, shooters and gunsmiths have sought a stock wood that remains stable in dimensions and shape as well as having other desirable characteristics. This, in turn, has motivated research for stock finishes that were waterproof and special bedding devices to hold stocks true under ever-changing weather and climate conditions.

Swelling, shrinking, or warping affect weapon accuracy. When exposed to water or higher-than-average humidity conditions, an ordinary wood stock will swell. When swelling occurs, the action becomes tighter, the forearm exerts more pressure on the barrel, and the rifle cannot maintain zero; in most cases, it will shoot very erratically.

When a stock is subjected to lower-than-normal humidity for a sustained length of time, the wood shrinks. The results are a poor fit of all stable fittings that go on a stock, such as horn or plastic forearm tips, grip caps, sling swivels, and inlays. Moreover, the action becomes loose in the stock and, if the barrel is bedded to the wood, it will not maintain zero.

Unstable rifle stocks are an expensive proposition because there is always the problem of tuning the rifle for its best accuracy, which takes time, ammunition, and the like. Many rifle barrels achieve their best accuracy when bedded to the wood in the forearm of the stock. With present-day rifle stocks, this is practically impossible for competitive shooting. But a rifle stocked with the barrel free-floating also requires tuning from time to time because of swelling or shrinking in the action area. When the rifle starts shooting erratically, it must be readjusted to fit the stock properly.

The gunsmith can certify as to the accuracy of a weapon when it leaves his shop. He cannot certify how long it will maintain that accuracy, because the stock is the one unstable element over which he has no control.

Finishes Ineffective as Humidity Blocks

Travel to and from humid regions affects weapon accuracy. The competitor or hunter who travels from a region of low humidity to one of high humidity, or vice versa, will experience gun trouble because the stock will shrink or swell, and perhaps warp. How soon this occurs depends on the conditions; however, regardless of stock finish, the present-day stock will adjust to its environment in 2 or 3 weeks and if the change is radical, much sooner.

A rifle stock will undergo a dimensional change from one season to the next if not protected from changing humidity conditions--something the average gun owner finds impossible to do. The craftsman who wants to do a first-class job of stocking a rifle needs to know the average humidity conditions of the area in which the rifle will normally be used. But this is often impracticable.

Suppose, for example, that he stocks a rifle for a customer in Phoenix, Ariz. It shoots accurately in the dry southwestern climate. But the pet rifle is taken to Alaska for an extended hunting trip during the wet fall season, and soon loses its fine accuracy. The stock may even swell and split. With present-day stocks there is no cure for this problem.

A Marine Rifle Team that left Hawaii to participate in the Hi-Power Rifle Championships at Twentynine Palms, Calif., in March 1960, found this out. They arrived 7 days before the match. By match day, the 10 percent relative humidity, average for this desert area, had caused their stocks to shrink and, in some cases, warp. The zeros that were good upon arrival were no longer valid. The fine accuracy was gone. As a result, the team was unable to make as fine a showing as had been expected.

Research Develops Methods for Stabilizing Wood

In the past, most efforts to stabilize wood have employed some sort of coating that would cut down, or if possible prevent, the movement of water vapor into the wood. In recent years, various "plastic" and other finishes have been advertised as the answer to this problem. Actually, some of the better coatings, especially the new polyurethane resin-base finishes, are temporarily highly effective in slowing the movement of water vapor into wood. No finish or coating now known, however, will prevent moisture from diffusing into wood.

Since the possibilities of developing fully effective, permanent coatings were not promising, research at the U.S. Forest Products Laboratory was early directed toward modifying the wood itself so that it would not change appreciably in dimension with variations in relative humidity. Several methods for stabilizing wood have been developed, at least three of which show promise for application to gunstocks.

The most successful to date, as this report demonstrates, is the polyethylene glycol process. Polyethylene glycol-1000 is a relatively new organic chemical of high molecular weight. It resembles paraffin wax and dissolves readily in warm water. In initial experiments it was found that when freshly cut green wood is soaked for an appropriate period in a water solution of this chemical, the wood does not shrink appreciably when dried. Equally important, wood thus treated and then dried swells very little when exposed again to high humidities.

Polyethylene glycol curbs shrinking, swelling, and warp by a process best described as bulking the microscopic, latticelike structure of the individual fiber walls. It isn't just a matter of filling the cavities of the tubelike fibers with an inert waxy substance. Instead, the chemical diffuses deep into the fine structure, where the natural moisture of the turgid wood fibers is displaced by the large molecules of the stabilizing agent. Fiber walls thus supported--bulked--are permanently restrained from shrinking as the green wood dries or from swelling as the dried wood again takes on moisture. The treatment thus attacks the problem at its very roots.

About 1,000 Stocks Tested

This new treatment was first tried on gunstocks at the Forest Products Laboratory, in cooperation with the Crane Creek Gun Stock Company, Waseca, Minn., in the fall of 1959. Since then, about a thousand experimental stocks, made of 10 different woods, have been treated and dried in various ways, and their performance checked in high- and low-humidity "torture chambers" (fig. 1), while immersed in water, and in service on the range and in the field. The perfected methods resulting from this research are now in commercial use. Full technical details have been published in various scientific journals. Reprints are available free of charge from the Forest Products Laboratory.

Reversing the traditional procedure, the stocks are first inlet and fully shaped from fresh-sawn green blanks. They are then soaked for from 10 to 30 days in a 50 percent water solution of polyethylene glycol-1000 maintained at temperatures of from 140° to 160° F. Treating is done in a wood-lined vat, and the solution is circulated continuously. Period of soak and temperature is varied according to the species of wood and the size and shape of the stock.

Treating schedules developed for military and sporter stocks are designed to attain a polyethylene glycol retention of from 25 to 30 percent (of the weight of dry wood) in the thin critical areas around the action and barrel groove, where a high level of dimensional stability is essential for top performance of precision rifles. Heavier treatment would result in deeper penetration of the chemical into the thick part of the butt, where a high level of stability is unimportant. This would be wasteful of chemical and would also cause an undesirable increase in the weight of sporter and military stocks.

Little Actual Weight Gained

Another factor operates to prevent an undesirable increase in weight. Since treated wood does not shrink appreciably in drying, there is less wood substance (mass) in a given volume of dry treated wood than in an equal volume of untreated wood dried by conventional methods. Even so stable a wood as walnut will, if not stabilized, shrink about 10 percent when dried to 6 percent moisture content, which means a proportionate increase in density. For these reasons, a properly stabilized sporter or military stock is little heavier than a comparable untreated stock.

The green precarved stocks, taken dripping wet from the treating vats, are placed in a modern kiln and dried by a special "ultradrastic" schedule to a uniform 6 percent moisture content in 20 days--compared to 120 days of combined air and kiln seasoning commonly used by industry just to dry untreated walnut stock blanks. In addition to savings in time and drying costs, the loss due to seasoning degrade--splits, checks, honeycomb--is now negligible.

Target Stocks Laminated

The practical effective depth of diffusion of the stabilizing agent into green wood is about one-half inch. Accordingly, it is simple to adequately treat (from both sides) the thin critical areas of precarved sporter and military stocks. However, the same methods are not equally effective in treating the wider and deeper forends of target stocks, which range up to 4 inches in width. In this case, 1-inch-thick green boards, bandsawn to desired shape, are first stabilized, then dried and surfaced.

These relatively thin, heavily treated "slats" are next laminated (glued together flatwise) into blanks of any desired thickness. The glued-up blanks are then shaped and inletted. The resulting laminated target stocks, unlike the solid-wood sporter and military stocks, are of course heavier than comparable untreated stocks. All wood therein, including that in the butt, is heavily treated. However, the resulting net increase in weight, about 20 percent, is not a disadvantage in target stocks. They are uniformly stable throughout, and have given excellent performance on the range.

Stabilization with polyethylene glycol has slight effect on the color, gluing, machinability, or physical properties of wood. It does however interfere with most finishes which adhere poorly and dry slowly on the rather waxy surface of the treated wood. Only a new polyurethane resin-base varnish has proved entirely satisfactory. This extremely hard, durable finish also locks the stabilizing chemical in the wood, preventing leaching even when immersed in running water.

Another kind of stabilized wood developed by the national Laboratory is called "impreg." In this process, thin sheets of veneer are placed in a steel cylinder and impregnated with phenolic resins under heat and pressure to a retention of about 30 percent. The treated veneer is then dried and laminated to the desired thickness with a resorcinol adhesive. The resulting product, impreg, is highly stable because of the bulking action of the phenolic resins. It can be soaked in water indefinitely, without swelling appreciably, and is highly resistant to rot, termites, and even marine borers.

Millions of board feet of impreg are used each year in various products. Probably the largest consumer is the automotive industry, which uses it to make die models for body parts. Impreg is preferred because it is highly stable, easy to work, and can be shaped to tolerances of a few thousandths of an inch.

The first solid impreg rifle stocks were frabricated by the Crane Creek Company from blanks produced at the Forest Products Laboratory. They were sent to the Marine Corps for evaluation in July 1960. As discussed in detail later in this report, the impreg stocks gave outstanding performance from the standpoint of weapon accuracy and consistency, but did not stand up well under the continual pounding of .30 caliber rifles shooting hot loads.

Acetylated Stocks Under Test

Wood can also be effectively stabilized by a rather complex chemical process known as acetylation. Following up on fundamental research at the Forest Products Laboratory, chemists of the Koppers Co. recently perfected what appears to be a practical method for producing acetylated wood in commercial quantities. Details of the process were published in the August 1961 issue of the Forest Products Journal. With this process, it is possible to stabilize dry wood in thicknesses up to about 3 inches. Acetylated wood is highly stable, can be soaked in water indefinitely without appreciable swelling, has high impact strength, and has no problems in gluing or finishing.

The only disadvantages of acetylated wood for use in gunstocks, so far as we can see now, are limited production, currently high cost, and the possibility that some residual acid in the treated wood may corrode metal parts of barrel and action. The first rifle stocks made of acetylated wood were produced in January 1962, by the Crane Creek Gun Stock Company, from material supplied by the Koppers Co., for evaluation by the Marine Corps. It is still too early to know how they will perform.

Marine Tests Begun in 1960

The Marksmanship Training Unit of the U.S. Marine Corps was first informed of Forest Products Laboratory's chemically stabilized stocks in June 1960. In late July, stocks made by both methods--glycol stabilization and impreg--were sent to Camp Matthews for inspection. Since that time, these stocks have been undergoing evaluation.

Two impreg stocks each of yellow birch, yellow-poplar, and cativo (a tropical American wood) were evaluated. In the initial phase, one stock of each species was fitted on .300 Magnums. The actions and barrels were bedded to the wood to facilitate detection of any movement of the stock. Glass bedding was not used in this first test. These three stocks were bench-rested at 300 yards for grouping qualities and accuracy, then fired in the machine rest for better determination of cold first-shot data as related to subsequent shots fired through a hot barrel. All three stocks performed satisfactorily.

When placed on the machine rest, with its stiffer recoil, the cativo stock split after five rounds. This had been anticipated, since cativo wood is very soft. The cativo and yellow-poplar (also a soft wood) required tightening of the guard screws on an average of every 60 rounds fired. This caused a movement of group placement on the target. The cativo stock was not tested further on these guns, but there is strong reason to expect it can be put to excellent use in the small-bore rifle field.

The remaining yellow birch and yellow-poplar impreg stocks were then fitted to the same .300 Magnums. The actions were glassed at the recoil lugs and guard screw areas, and the barrels were again bedded to the bare wood in the forearm. The stocks were then put through the identical tests given the first ones. After initial tuning, no further work was required. This test was completed in January 1961.

Rate High in Matches

The rifles, as stocked, were later placed in competition and have had several 18V possibles at 1,000 yards. They were subjected to extremely high humidity, averaging 89 percent, for 3-1/2 months when taken to Quantico, Va., the site used for training the Marine Corps National Rifle Team. During this period, 36 long-range weapons that had been mounted on untreated stocks before shipment from the 59 percent humidity of the West Coast had to be disassembled three times and the barrel channels opened up because of swelling.

The two chemically treated stocks did not require tuning or stock work of any nature during this period. Moreover, when they were taken to the 1961 National Matches at Camp Perry, Ohio, scores of 100-18V were attained with them in the 1,000-yard competition (fig. 2). They performed equally well in all competitions entered. First-shot, cold-gun data remained consistent, and climb rate, as the rifles heated up, was reduced by 25 percent.

Evaluation results indicate that: (1) resin impregnation produces an extremely stable stock with real beauty; (2) the resin makes the wood brittle, causing exposed edges to chip easily; (3) the stock is not suitable for checkering; and (4) the resin adds appreciable weight to the stock. In view of these findings and the more favorable all-round results gained from evaluation of the polyethylene glycol-treated stocks, it was recommended that the impreg stocks be dropped from further evaluation for use on large-bore rifles.

On the other hand, stocks for small-bore rifles, made from a laminated "sandwich" having an impreg core with glycol-stabilized walnut faces, show great promise. Several such stocks (fig. 3), fabricated by the Crane Creek Gun Stock Company, are reported to have given excellent performance in recent small-bore competition. The action and barrel are bedded metal to wood in the impreg core, thus taking advantage of the fine stability of this material; the recoil of the small-bore rifles is not sufficient to result in splits; and the surrounding glycol-stabilized walnut effectively protects the impreg core from chipping. Used in this way, impreg seems to have a promising future for high-grade, small-bore target stocks. Impreg sells for around $6 per board foot, about twice the cost of glycol-stabilized wood.

Polyethylene Glycol-Stabilized Stocks Evaluated

The Forest Products Laboratory, in cooperation with the Crane Creek Gun Stock Company, provided the following glycol-stabilized stocks: Two walnut M1 stocks, two walnut 3-ply laminated varminter stocks, one walnut sporter stock, and one Hawaiian mango sporter stock. These stocks were placed on rifles as listed below for evaluation of the glycol treatment.

Two walnut M1 stocks glassed for the same M1 service rifle.

One walnut 3-ply laminated varminter stocked on a Model 70 action, medium-weight barrel, chambered for .308 caliber.

One walnut 3-ply laminated varminter stocked on a Model 95 Mauser action, chambered for .243 caliber, heavy barrel with five flutes.

One walnut sporter stocked on Model 70 action, medium-weight barrel, chambered for 30.06 caliber.

One Hawaiian mango sporter stocked on Model 70 action, with national match medium-weight barrel, chambered for 30.06 caliber.

All bolt actions were glassed lightly at the recoil lug and guard screw areas only. The barrels were bedded to the forearms under 6 to 8 pounds of pressure. The M1 actions were glassed to the stocks as prescribed for national match M1 rifles, and in such a manner as to have the stock ferrule maintain about 18 pounds of pressure downward on the hooks of the lower band.

These stocks were evaluated under varied conditions and in numerous locations in the United States (fig. 4). At Quantico, during the training period, the two M1 polyethylene glycol-treated stocks, along with one untreated stock, were glassed to a single M1 action of known quality and performance. They were test-fired at 1-week intervals from mid-June to mid-August, 1961, on the machine rest at 300 yards.

During the first week of testing, the target groups for all three stocks averaged a 4-1/2-inch extreme spread, using Field Artillery Match ammunition.

Untreated Stock Erratic

In subsequent weeks, the untreated stock gave erratic group placement, and group size varied from 4-1/2 to 8 inches in extreme spread. The polyethylene glycol-treated M1 stocks, however, remained consistent in group placement, and group size varied from 3-1/2 to 5 inches for an average of 4-1/2 inches.

In September, the test rifle and stocks were sent to Camp Matthews, Calif. The tests were resumed in October and lasted through November under average humidity conditions of 59 percent. The treated stocks gave no indication

of a zero change; group placement and size remained consistent with previous tests. The untreated stock, however, required adjustment of a 3-minute change in wind and a 2-minute change in elevation. Group size stabilized out at about a 6-1/2-inch extreme spread.

Evaluation of the 3-ply laminated walnut varminter stock on a Model 70 action in .308 caliber was conducted at Camp Matthews (fig. 5). The action was glassed and the mediumweight barrel was bedded to the forearm. This weapon fired consistent minute of angle groups (fig. 6, upper). Even after 2 months in the high humidity environment of Quantico, it retained its minute of angle group and group placement.

In September 1961, this rifle was sent to Barstow, Calif., in the Mojave Desert, where the average relative humidity is 10 percent, to see what effect the dry desert climate would have on the stabilized stock. After 4 months, no change could be detected in its grouping qualities, placement (fig. 6, lower), or fit of action and barrel to the stock. Nor was there any indication that wood shrinkage affected the fit of other stock accessories.

Survive 10-Day Water "Bath"

The Hawaiian mango sporter, the walnut sporter, and the other 3-ply laminated walnut varminter were fitted to barreled actions at Camp Matthews and test fired for group placement and size. When it was determined that they would shoot close to a minute of angle at 300 yards, they were prepared for a water immersion test.

The testing personnel were satisfied by this time that the polyethylene glycol-treated stocks were extremely stable for normal conditions in almost any area of the country. But how would these stocks react to the most adverse conditions possible? Was this treatment as good as indicated by laboratory tests? If so, the stocks should remain stable even though completely submerged in water for a 10-day trial period.

For this test, the three glycol-stabilized stocks noted above, two similarly stabilized M1 stocks, one impreg stock, and two untreated stocks were used (fig. 7). Before the test, all stocks were removed and refinished, careful attention being paid to end-grain areas. The finish on the polyethylene glycol stocks was renewed with the recommended stock finish--a polyurethane resin-base varnish. The impreg stock and the two untreated stocks were refinished with a standard silicone finish.

Previous tests of metal preservatives had indicated that "Rig Universal" gun grease would protect all metal parts from rusting during the 10-day water test. Before reassembly of the weapons, therefore, all metal parts of the triggers, actions, and barrels that are normally covered by the stock were given a liberal application of "Rig."

A 50-gallon barrel was filled with sufficient water to cover the stocks when set on end in the barrel. Weapons and stocks were submerged for the full 10-day period (fig. 8). They were then removed from the barrel, and excess water was blown out of the actions and off the stocks with a compressed-air hose. The sights were replaced and the weapons were test fired immediately.

The results of these tests are presented in table 1.

Swelling in Water Low

The chemically stabilized stocks maintained zero for group placement. Dimensional swelling midway across the action remained well within the expected 10 percent of that of untreated stocks. The untreated M1 stock swelled so much that the butt plate could not be replaced on it, and it developed three splits (fig. 9).

The test also demonstrated that end-grain areas of stocks must receive special attention. Conventional finish material is not adequate; special sealer compound should be used. Finish deterioration started at end-grain areas; dark streaks formed under the finish, and complete deterioration followed. The special polyurethane finish recommended for stabilized stocks stood up much better than the conventional finish used.

Shooters Want Proof!

How is the chemically stabilized stock being accepted by the shooting fraternity? As anyone who has worked with shooters knows, most of them are "from Missouri"--they demand to be shown!

Members of the Marine Marksmanship Training Unit were understandably skeptical at first. It is startling, and perhaps beyond the immediate comprehension of the uninformed, to be told that a gunstock can be ready for stocking on a rifle 30 days from the day it was cut off the stump! It was necessary to explain to our Marine marksmen the entire treatment procedure; to show "30-day-wonder" stocks made from wood types they knew to be extremely wild in the curing and drying stages; and to show results of comparison tests on treated and untreated stocks. But the evidence became so compelling that even the strongest skeptics were won over!

It is amazing, to one who has studied the performance of treated stocks, that so few people have yet grasped the military significance of this development and what it can mean to the age-old problem of procuring suitable gunstock material. For national defense, the development is of prime importance, because the long seasoning process heretofore necessary for costly woods like walnut, with its high degrade due to splitting and warping, can be reduced to weeks instead of months.

Only two types of wood are considered dimensionally stable enough and otherwise suitable for military rifles. When treated with polyethylene glycol, many species of wood can be used, there is practically no seasoning loss, and supplies become practically limitless. Coupling these procurement advantages with the demonstrated fact that the treatment makes the military rifle for the first time able to withstand any condition of humidity and temperature the world over, the polyethylene glycol-stabilized gunstock is a solid contribution to national defense.

Treatment Improves Workability

Yet there are more worthwhile advantages. The workability of polyethylene glycol-treated wood is in many ways improved. It machines better and to closer tolerances without danger of chipping. It is easier to hold to a true line. All cutting-tool operations are facilitated.

Work performed with rasp or sandpaper will require coarser grit than normally used, because the polyethylene glycol tends to clog the finer grits of sandpaper and fine-toothed rasps or files. When sanding for the final finish with fine-grit sandpaper, it was found that if the stock was wiped down with a rag soaked in wood alcohol, the surface polyethylene was cut off and sanding made easier.

The alcohol wipe is also used to advantage before applying the first coat of polyurethane resin-base finish. This procedure permits the first coat of finish to set and dry more quickly. The finish material can be applied by hand rubbing, sprayer, or brush. All the stabilized stocks used in this evaluation were provided by Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, in cooperation with the Crane Creek Gun Stock Company, Waseca, Minn. The latter is at present the only known commercial maker of polyethylene glycol-stabilized gunstocks. This firm also has available do-it-yourself kits for making stabilized rifle stocks.

The Marine Marksmanship Training Unit is continuing its evaluation of various types of stabilized stocks. Included in the program are additional M1 stocks, a recent shipment of 12 stabilized M14 stocks, and some target stocks made of wood stabilized by the acetylation process. In addition, 22 polyethylene glycol-stabilized, laminated stocks have been procured for use on long-range bolt weapons for competition (figs. 10, 11). It has been recommended that sufficient stocks be procured to equip the entire Marine Corps National Rifle Team.

Table 1.--Water-immersion 10-day test results

Stocks	Stabilization treatment	Dimensions midway across action			10-shot average group extreme spread				Finish applied	Finish deterioration
		Before test	After test	Swelling	Before test		After test			
					Elevation	Wind	Elevation	Wind		
		Inches	Inches	Inch	Inches	Inches	Inches	Inches		Percent
Walnut 3-ply varminter, Model 95 Mauser, .243 caliber	Polyethylene glycol	1.990	1.995	+0.005	2-5/8	3-3/8	2-3/4	3-1/2	Polyurethane resin-base	10
Hawaiian mango sporter, Model 70, 30.06 caliber	do	1.996	1.999	+.003	3-3/8	4-1/4	3-3/4	4-7/8	do	15
Walnut sporter, Model 70, 30.06 caliber	do	1.989	1.995	+.006	3-1/2	2	2-3/4	3-3/4	do	10
Yellow-poplar, 1/8-inch laminations, Model 70, .300 Magnum	Phenolic resin impregnation	1.998	2.002	+.004	2-1/4	4-1/2	2-1/2	3	Satin silicone	35
M1 service rifle, 30 caliber, No. 1	Polyethylene glycol	1.898	1.908	+.010	4-1/4	2-7/8	4	4-1/2	Polyurethane resin-base	5
M1 service rifle, 30 caliber, No. 2	do	1.894	1.905	+.011	3-7/8	3	3	4-1/2	do	5
M1 service rifle, 30 caliber, No. 3	No treatment	1.911	2.010	+.099	5-1/2	5-3/8	9	3	Satin silicone	100
Walnut target, Model 70, 30.06 caliber	do	1.931	2.023	+.092	3-1/2	3-1/8	6-3/4	4-1/2	do	75

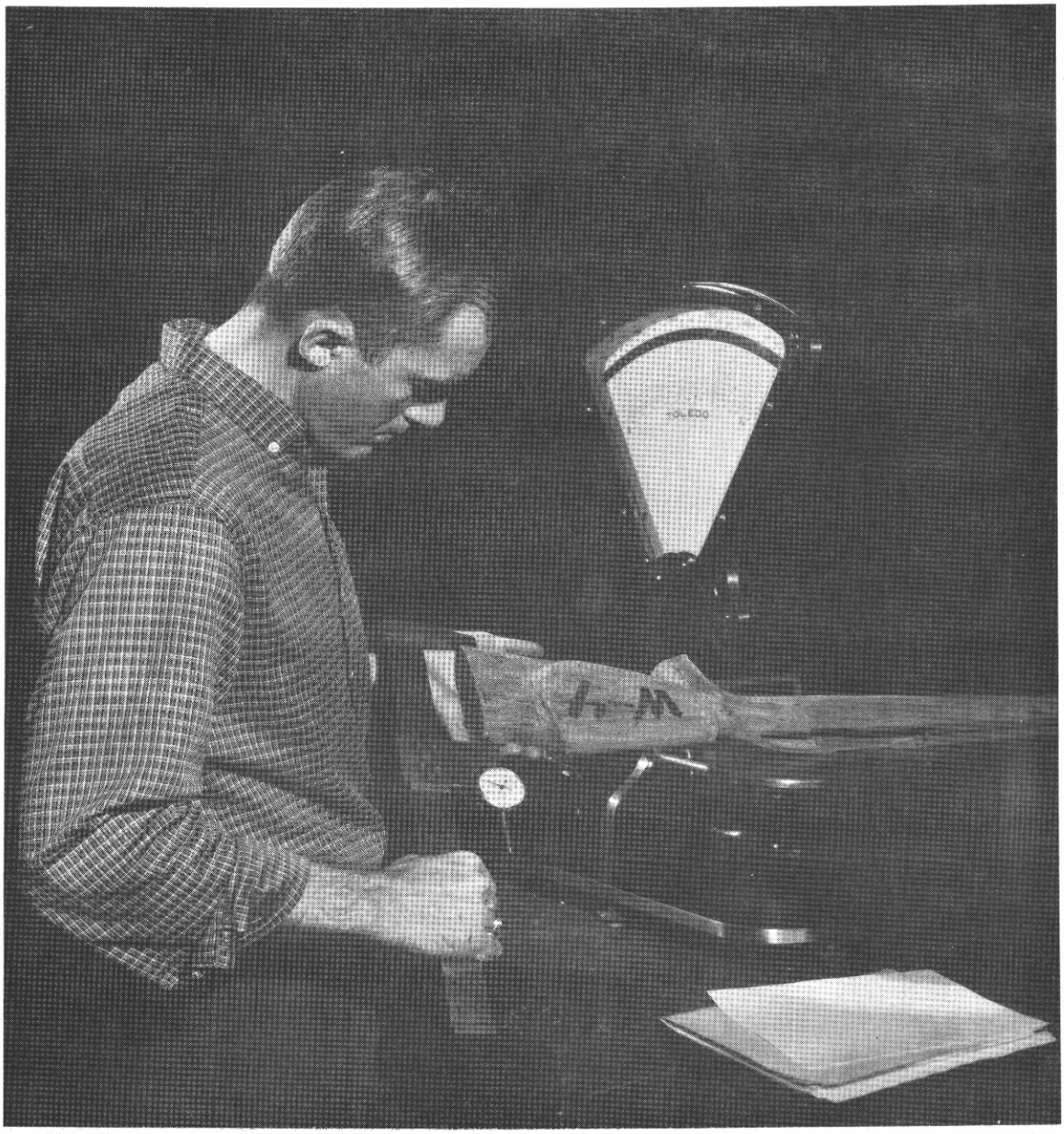

Figure 1. --Wood technologist at Forest Products Laboratory must use micrometer to detect negligible swelling of stabilized stock after 3 months' exposure to 95 percent humidity, 85° F. temperature. Weights were checked with balance shown.

ZM 116 405

Figure 2. --Colonel R. M. Wood, Head of Marksmanship Branch, Headquarters USMC, Washington, holding one of the impreg-stocked target rifles used by Marine Corps in 1961 National Matches at Camp Perry, Ohio. At right is Mr. H. L. Mitchell, of the Forest Products Laboratory, who did the pioneering research on stabilized stocks.

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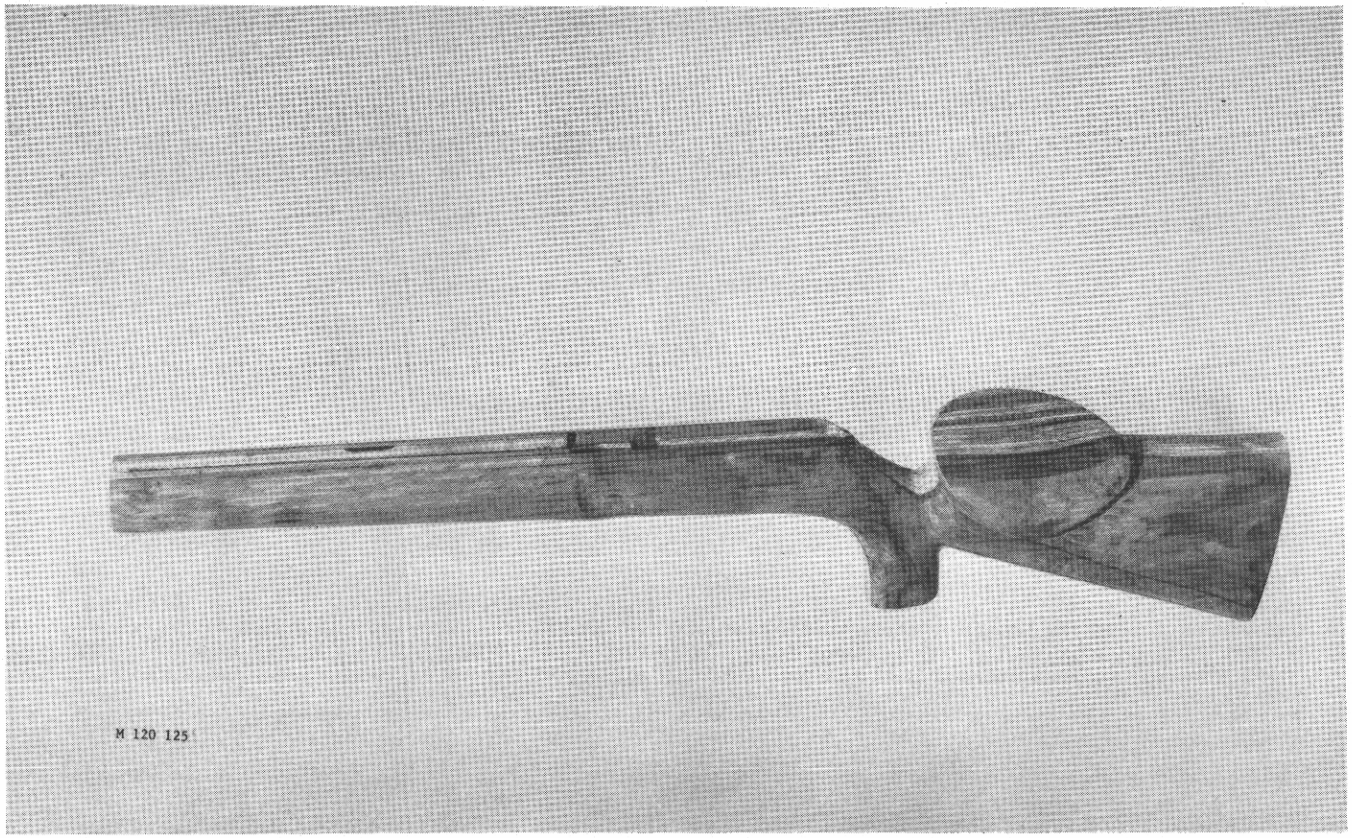

Figure 3. --Small-bore target stock made of built-up "sandwich" with impreg core protected by glycol-stabilized walnut faces.

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Figure 4. --Inspecting chemically stabilized rifle stocks at Marine Corps Headquarters at Camp Perry, Ohio, during 1961 National Matches. Left to right are: Major Robert E. Dawson, in charge of Marine Corps Rifle and Pistol Team, Mr. H. L. Mitchell of the U. S. Forest Products Laboratory, and Marine Major Generals August Larson and Fredrick L. Wieseman.

ZM 120 149

Figure 5. --Gy. Sgt. D. L. Smith, Marksmanship Training Unit, USMC, bench resting, at 300 yards, glycol-stabilized 3-ply laminated walnut varminter stock fitted to Model 70 action, cal. 30. 06, Douglas barrel. Forearm is still unshaped. See figure 6 for 10-shot groups.

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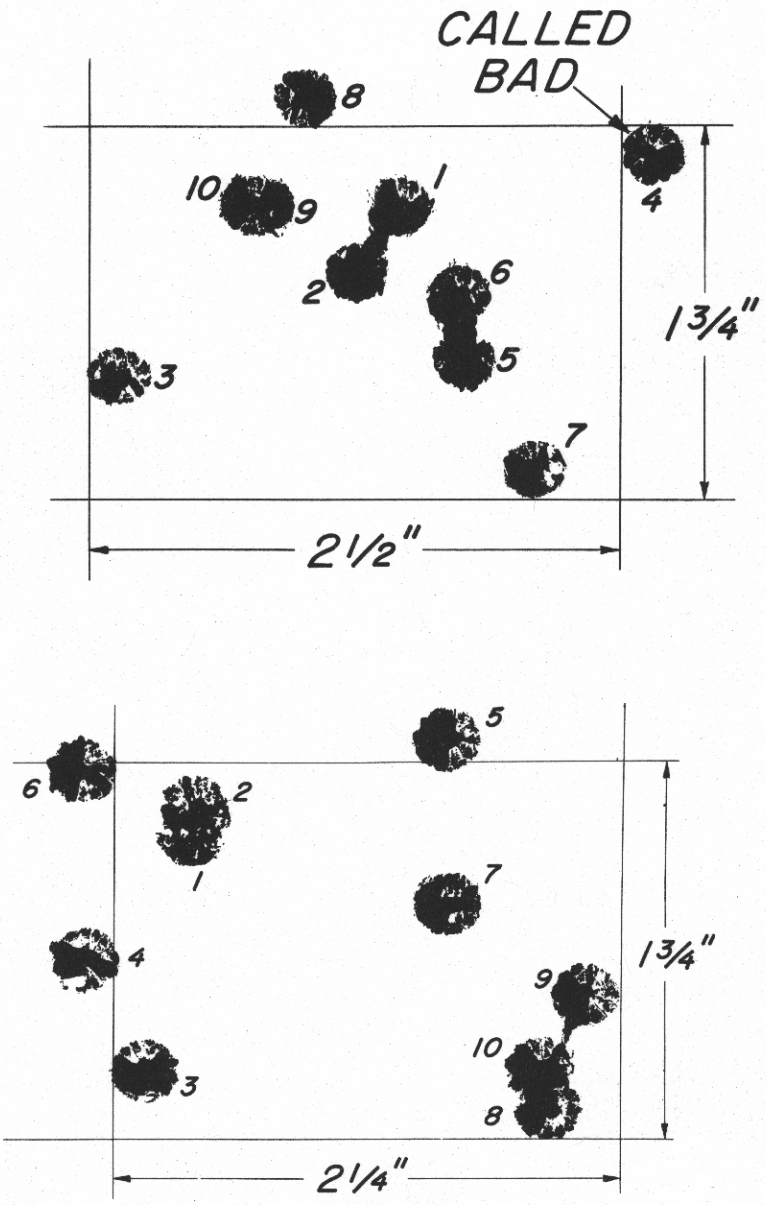

Figure 6. --These two 10-shot groups were shot at 300 yards, bench rest, with a glycol-stabilized, 3-ply laminated walnut varminter stock, fitted to the rifle shown in figure 5, under the following conditions: Upper, at Camp Matthews (relative humidity about 59 percent); and (lower) after 4 months at Barstow, California, in the Mojave Desert (relative humidity 10 percent). During period of test no adjustments were made in stock, rifle, or fittings.

ZM 120 679

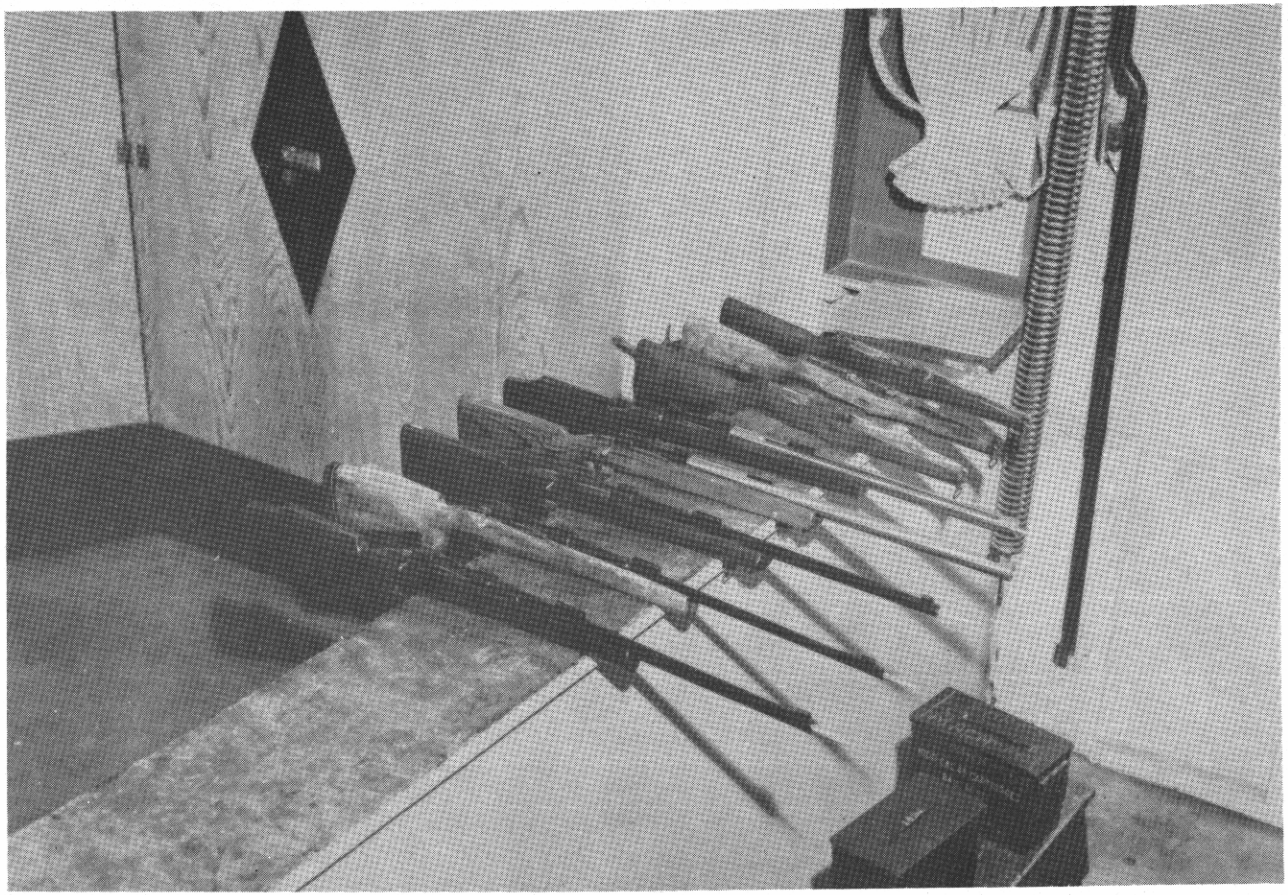

Figure 7. --Untreated and stabilized stocks just previous to immersion in water for 10 days at Camp Matthews, California.

ZM 120 651

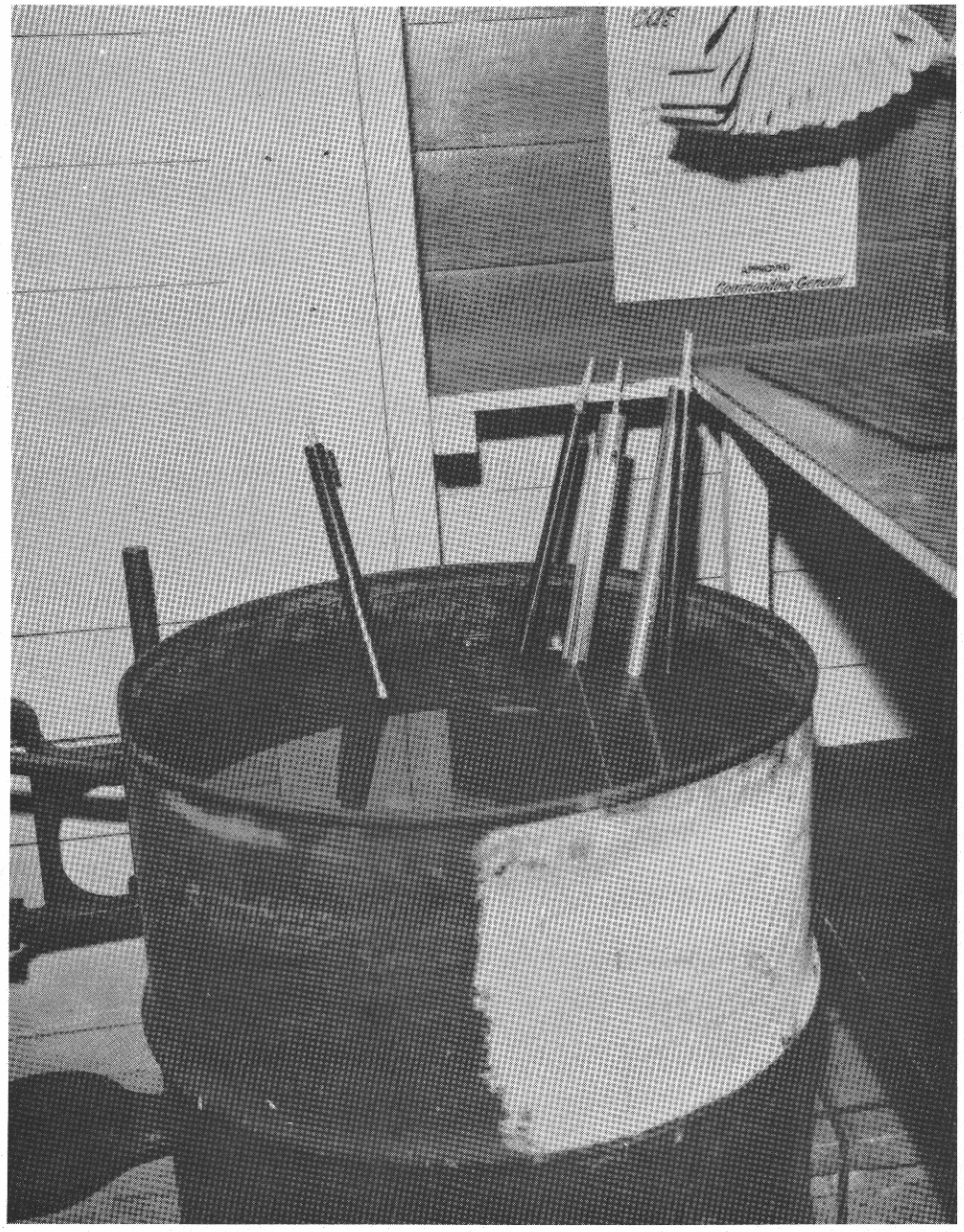

Figure 8. --Untreated and stabilized stocks shown during 10-day soak in barrel of water at Camp Matthews, California.

ZM 120 650

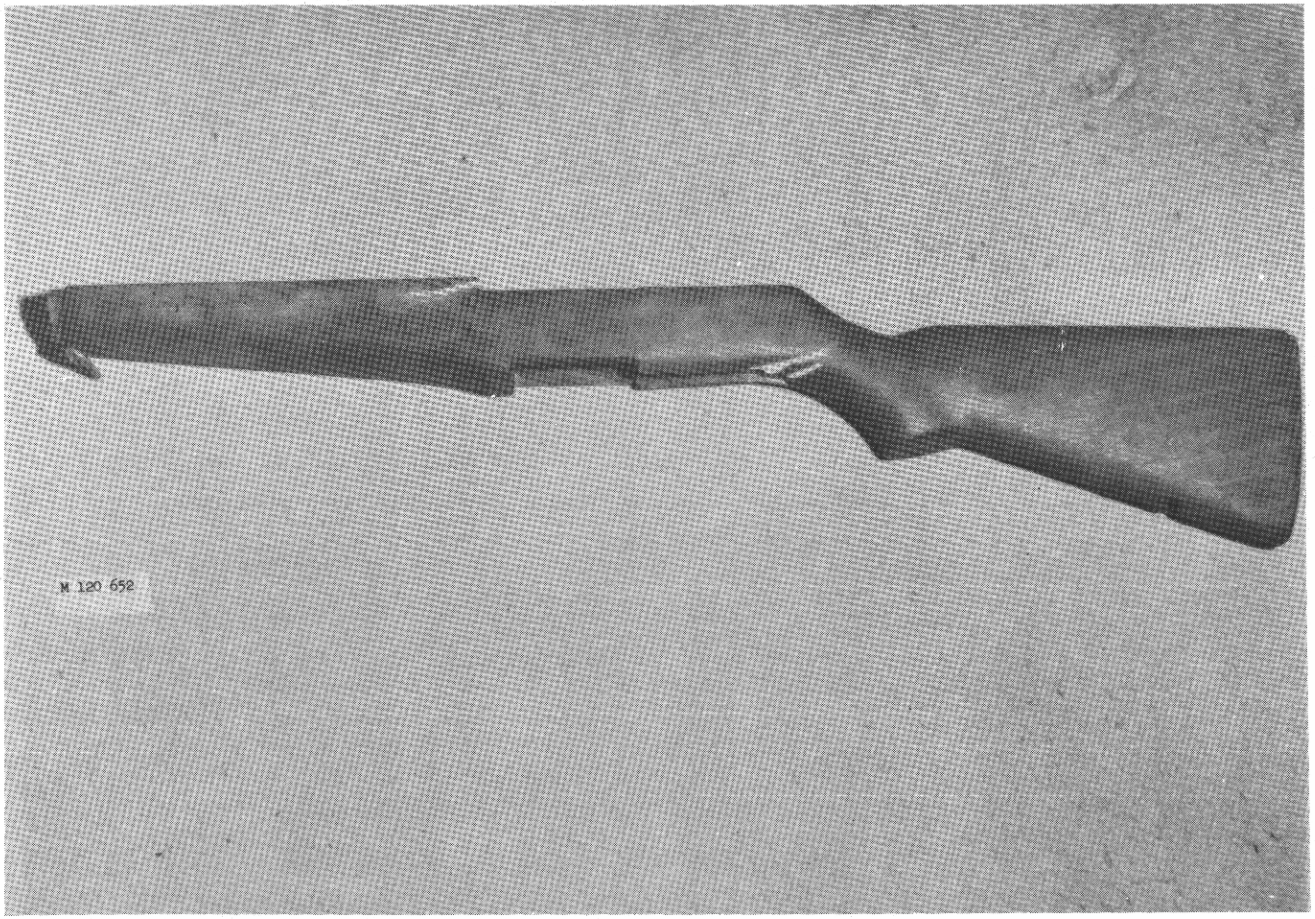

Figure 9. --Untreated M1 stock showing splits and checking that developed following immersion in water for 10 days. Swelling at butt was so great that butt plate could not be replaced. The stabilized stocks showed no checking or splitting, and swelling was negligible.

ZM 120 652

Figure 10. --Marine Corps national match prone stock. The one shown here is made of walnut, 5-ply laminated, glycol-stabilized. Other stabilized woods used in fabricating these stocks include cherry, bird's-eye maple, yellow birch, sycamore, and Hawaiian mango.

ZM 120 551

Figure 11. --Marine Corps national match course stock (r.) made of Hawaiian koa, 3-ply laminated, glycol-stabilized, and (l.) commercial varminter stock made of walnut, 3-ply laminated, glycol-stabilized.

ZM 121 082