It is the object of my invention to make bent-wood articles, especially thick articles, that will maintain their proper shape and dimensions after being bent; and, incidentally, at the same time to make such articles of pieces that are thinner and therefore less costly.

There are many places where it would be advantageous to use bent-wood articles, but where they have not been used in the past because of the apparently unavoidable tendency of such bent wood, especially in the thicker articles, to change indeterminately in shape and dimension over a considerable period after the bending—a period that may continue for weeks and months. For instance, in certain automobile-body bows, made of wood an inch or more thick and having an intermediate portion that is relatively straight or nearly straight and end portions that are bent into approximate quarter-circles, a prohibitive change in dimension, sometimes in excess of an inch, occurs in the distance between the two ends when these parts are made of single-piece bent wood. This change is an uncertain thing, for sometimes it is a lengthening and sometimes a shortening; and it has heretofore largely prevented the adoption and use of bent wood in many places where otherwise it is well adapted for use.

Probably this uncertain change in shape and dimension has been the result of heavy local stresses set up in the wood structure during the bending. As the bending is done, even of wood carefully steamed, there is some stretching at and near the outer surface of the bend and a greater compressing and upsetting at and towards the inner surface of the bend. The degree of this stretching, and of this compressing and upsetting, and therefore the difference between effects on the wood structure at and near the outer and inner surfaces respectively, increases with the thickness of the wood; so that while relatively small in thin veneer it becomes very large in thicker pieces, say of an inch thickness and upwards.

It has been proposed to make these thicker bent-wood articles of several plies, bent separately and then glued together. While this has helped some, by lessening to some extent the distortion following bending, it has not been of sufficient help to make bent wood generally available for parts requiring any real constancy of dimension.

I have found, however, that it is possible to obtain much greater constancy of dimension in bent-wood articles, and a constancy that is well within commercial limits even in thick articles, by making such articles of a plurality of plies which while softened by steaming are bent simultaneously and while in contact in the relative order they are to have in the finished article, so that each ply serves as a form for its neighbor or neighbors in the bending operation; then letting the bent group of plies dry and set while held together; and then gluing said plies together. The built-up article thus made may be worked and finished in the usual manner, just as if it were of one piece.

For instance, an article that in the rough is to be an inch and a half thick may be built up of three plies each a half-inch thick, or of two plies each three-quarters of an inch thick, or of four plies each three-eighths of an inch thick, or of one three-eighths-inch and one half-inch and one five-eighths-inch ply.

The abutting surfaces of the adjacent plies slide on and conform to each other during the bending, and thus avoid the production of the heavy stresses that are produced in the wood structure when the same bending is done of a single piece equal in thickness to the combined thickness of the group of plies. The drying and setting of the plies while they are kept in contact results in the avoidance of relative distortion between the plies which are to be in contact in the finished article. The gluing together of the group of plies after they have dried and set holds them in the proper relative position, with relatively little stress in the wood structure in comparison with that existing in a corresponding single-piece article, and with the stresses which do exist in the separate plies largely balancing each other because of the
resistance which the glued surfaces present against the relative slipping that any distortion would tend to produce.

In the accompanying drawings I have illustrated my invention in connection with the making of multi-ply automobile-bows. Figs. 1, 2 and 3 are front elevations of a group of plies of lumber that are to form a multi-ply automobile-bow, in initial position prior to bending, in partly bent position, and in completely bent position ready for drying, respectively, and show also the bending form and fragmentally some parts of the bending machine, which per se may be of any desired type; Fig. 4 is a perspective view of a plurality of such groups that were all bent simultaneously in the bending machine, held ready for drying in the form in which they were bent; Fig. 5 is a perspective view of the same plurality of groups, after they have dried and set sufficiently to be removed from their bending and retaining form; Fig. 6 is a perspective view showing several plies of a group that is to form one automobile-bow, separated for applying the glue; Fig. 7 is a plan showing the same three plies put back together again after the applying of the glue and held together on a gluing form while the glue sets; and Fig. 8 is a perspective view showing a multi-ply automobile bow, in the rough at one end and finished at the other.

The lumber of the proper thickness for the various plies is cut into the desired lengths, finished flat as by planing on the surfaces which are to lie against other surfaces, assembled in groups with such flat surfaces together and in the order they are to have in the finished article and temporarily held together in said groups by one or more nails 10, which although shown driven home are not necessarily so and which are later removed, and given the usual steaming treatment which is shown and held temporarily to bend the assembly into groups may be either before or after the steaming, but is most conveniently before steaming. The different plies of a group are of suitably different lengths graduated from the shortest length for the ply that is to be on the inner side to the greatest length for the ply that is to be on the outer side of the article after the bending. In the example shown, the article to be made is an automobile bow, and is made of three plies 11, 12, and 13 of successively greater length, so that the shortest ply 11 will eventually be on the inner side and the longest ply 13 will eventually be on the outer side.

After the lumber has been softened by the steaming, one or more of the assembled and steamed groups are put on a suitable form 15, (of which there are a number,) and bent into the desired shape in the usual bending machine. As bending machines are well-known, I have shown merely the fixed forming blocks 16, fragments of the movable bending bars 17 and of the pull-chain 18 thereof, the flexible work-supporting strap 19, which interconnect the bending bars 17 and on which the form 15 lies, and the rigid bed 20 on which the middle part of the strap 17 lies. These fixed forming blocks 16 are shaped accurately to the desired shape of the inner face of the article when the latter is fully bent. The forms 15 are of flexible sheet metal, such as sheet brass, usually of sufficient width to hold a number of bows, four as illustrated; and at their ends have rigid end-pieces 20 which have upturned end flanges 21 between which the plies of lumber lie. As the bending is done, by the simultaneous pulling of the two chains 18 and the resultant simultaneous tilting of the two bending levers 17 which 21 successively engage the ends of the plies, the longest or outer ply first and the shortest or inner ply last, as the ply-portions which are being bent slide on each other from their initial flat position shown in Fig. 1 through their intermediate position shown in Fig. 2 to their fully bent position shown in Fig. 3. In this fully bent position, the bent portions of each ply lie tight against its neighbor or neighbors, between the forming blocks 16 on the inside of the bends and the metal of the flexible forms 15 on the outside of the bends; and the end flanges 21 bear tightly against the ends of all the plies and by their reaction hold the plies tight against one another.

When the bending has been done, the bent ends of the usual tie rods or tension rods 25 are put into holes in the end-flanges 21, and stretcher frames or bars 26 are put in place as thrust blocks between the bent end-portions of the groups of plies, as is clear from Figs. 3 and 4. Then the form 15 with its load is removed from the bending machine and the wood on it is suitably dried; and another form 15 is put on the bending machine for the next load. When the wood on a form is set it may be removed from the form 15, as is shown in Fig. 5, and if more drying is to be done it may be done in any usual manner.

When the wood is fully dried, which may require several days, the plies of a group are separated, as shown in Fig. 6, and glue is applied to the various abutting surfaces thereof. Then the group of plies is properly reassembled in the same order as during bending, and desirably in the same relative positions although in suitably symmetrical articles it is not unduly harmful if one or more of the plies are turned end for end with relation to the other plies. Then the group of plies is put on a gluing form 30, on which the reassembling itself may be done, and the plies pressed firmly together and the inner ply pressed against the gluing form by any suitable clamping means; as shown by simple carpenter's clamps 31 which each have one
The process of making a bent-wood article, comprising bending a plurality of steamed superposed plies of lumber so that each ply serves as a form for its neighbor or neighbors, then letting the assembled group of plies dry and set while they are held together, and then gluing said plies together in the same relative order they had during the bending.

3. The process of making a bent-wood article, comprising bending simultaneously a plurality of steamed superposed plies of lumber so that each ply serves as a form for its neighbor or neighbors, then letting the assembled group of plies dry and set while they are held together, and then gluing said plies together in the same relative order they had during the bending.

4. The process of making a bent-wood article, comprising bending a plurality of steamed superposed plies of lumber so that each ply serves as a form for its neighbor or neighbors, then letting the assembled group of plies dry and set while they are held together, and then gluing said plies together in the same relative order and positions they had during the bending.

5. The process of making a bent-wood article, comprising bending a plurality of steamed superposed plies of lumber so that each ply serves as a form for its neighbor or neighbors, then letting the assembled group of plies dry and set while they are held together, and then gluing said plies together in the same relative order and positions they had during the bending.

6. The process of making a bent-wood article, comprising bending simultaneously a plurality of steamed superposed plies of lumber so that each ply serves as a form for its neighbor or neighbors, then letting the assembled group of plies dry and set while they are held together, and then gluing said plies together in the same relative order and positions they had during the bending.