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FLUMES AND FLUMING.[1]

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INCREASING IMPORTANCE OF FLUMES.

The growing scarcity of accessible areas of virgin forests from which timber can be transported cheaply by streams to central points for manufacture has called into being additional systems of handling and transporting logs and timber, as exemplified in the different forms of railroad logging, and in such adjunctive features of logging as donkey engines, overhead cableway skidders, flumes, etc.

Repeated inquiries for information regarding flumes and flume construction are responsible for the present discussion. This method of transportation may be classed as an amplification of log driving, through using water as the transporting medium, but in a much smaller quantity and in a more closely confined and controlled form through the aid of artificial and smoother "banks," as represented by the sides of the flume. It also gives to the operator the additional advantage of being able to direct the transporting agency, under certain fixed limitations, to a desired point sometimes far away from any natural stream of water.

The use of flumes for transporting timber or lumber from localities which at the present time are commercially unprofitable to log will undoubtedly increase in the future. There are large areas of privately owned timber in the higher elevations of the mountainous regions which could be taken out if the cost of logging could be brought low enough to insure a reasonable profit to the operator, and there are a great many localities in the National Forests, which in most cases include the tops of the mountain ranges, where the construction and use of certain types of flumes using the minimum amount of water will make it possible to remove the timber or lumber with the aid of the small streams having their rise in the mountains.

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[1] Discusses the use of flumes in lumbering operations and tells how to build them. Of especial value to lumbermen and log drivers.

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This increased usage will simply be the logical result of conditions. The removal of timber by flumes from many localities is to-day the only economical method. There are a great many localities where timber is at present being taken out at a loss, but where, if an up-to-date flume had been built at the inception of the lumbering operation, instead of starting with the methods at present used, much more satisfactory results would have been shown.

FORMS OF LUMBER TRANSPORTED BY FLUMES.

The different forms in which lumber or timber is generally transported by flumes at the present time are as follows:

(1) In logs.
(2) In piling, mining "stulls," or long timbers.
(3) In railroad crossties.
(4) In "cants" or split-log form.
(5) In lumber "loose" boards or planks.
(6) In lumber "brailed" or clamped together.
(7) In cordwood or pulpwood.

There is hardly any limit to the forms in which lumber may be transported in flumes, provided it is of a species that will float and the flume is constructed with due regard for the material to be handled. The logging conditions, species and character of material to be handled, amount of water available for fluming purposes, etc., all have a very direct bearing on the form of flume and the methods used in construction. Thus, in a locality where the supply of water is ample and there is no necessity for husbanding it, a type of flume might be used which in another locality where there was a scarcity or lack of water might be very undesirable.

The very important feature of water supply has, in fact, had much to do in determining the type of flume that is being used in different localities; since where water is plentiful and there is no particular need of being economical in its use, a square or box-like flume of almost any size will do for either logs or lumber, while in other localities it has been found absolutely necessary, on account of the small volume of water available or for other reasons, to use a type of flume which, with approximately one-half the volume of water necessary in the square or box type of flume, will handle practically the same class of material. Thus it is quite common in the Appalachian Mountain region to see box or square sided flumes in use, while in the mountainous western portions of the United States the square-box flume is rarely seen, and the V-shaped flume is the one in general use. Necessity, therefore, has in the past and undoubtedly will in the future be the principal factor in deciding what type of flume shall be constructed.

TYPES OF FLUMES.

There are only two types of flumes in general use in the United States at the present time—

(1) The box or square upright-sided flume.

(2) The V-shaped flume.

The square flume is usually constructed along the general lines of the well-known mill flume or artificial conduit used to convey water from the mill pond to the mill for water power or other purposes, but with this difference, that the uprights on the sides of the square or box timber flume are rarely braced across the top of the flume, but instead the top of the flume is left open to afford free passage for logs, wood, or lumber, and the sides are held in place by uprights fastened on the sills or crosspieces on which the bottom of the flume rests, and braced from the outside. (See fig. 1.)

This is the oldest type of wooden flume in use, and is employed to some extent at the present time where economy in the use of water is not of any particular importance. However, the square flume requires more water to operate successfully with the same class of material, and, generally speaking, requires more lumber for construction than does the V-shaped flume. Furthermore, the material being handled is more apt to "jam" (especially the short material) in the square-box type. Owing to the form of its construction there are more joints in this type that are liable to open up and cause "leakage," in case the flume is allowed to stand without water running in it for any length of time, and except where it is desired to combine in one flume the two objects of carrying a large amount of water to be used for some purpose other than fluming below and at the same time to use the flume for the transportation of lumber or timber, it is generally more advisable to use the type of flume which requires the least amount of water and the least average amount of repair. Up to the present that is the V-shaped wooden flume, but it is perhaps not a flight of fancy to predict that it is only a question of time when strong and light "sectional" metal flumes, semicircular in form, that can be quickly taken apart and transported from one point to another and put together and set up again, will be in common use. Metal semicircular conduits, made in sections and easily put together, have already been used in hydroelectric and irrigation projects.

There is a conduit of this character in operation on the Sierra National Forest in California, and the writer sees no reason why a similar type of metal conduit, lighter in construction and somewhat modified in form, could not be developed for log or lumber flumes. The initial cost of construction would, of course, be considerably greater than for a wooden flume, but the metal one would have much greater durability and length of service.

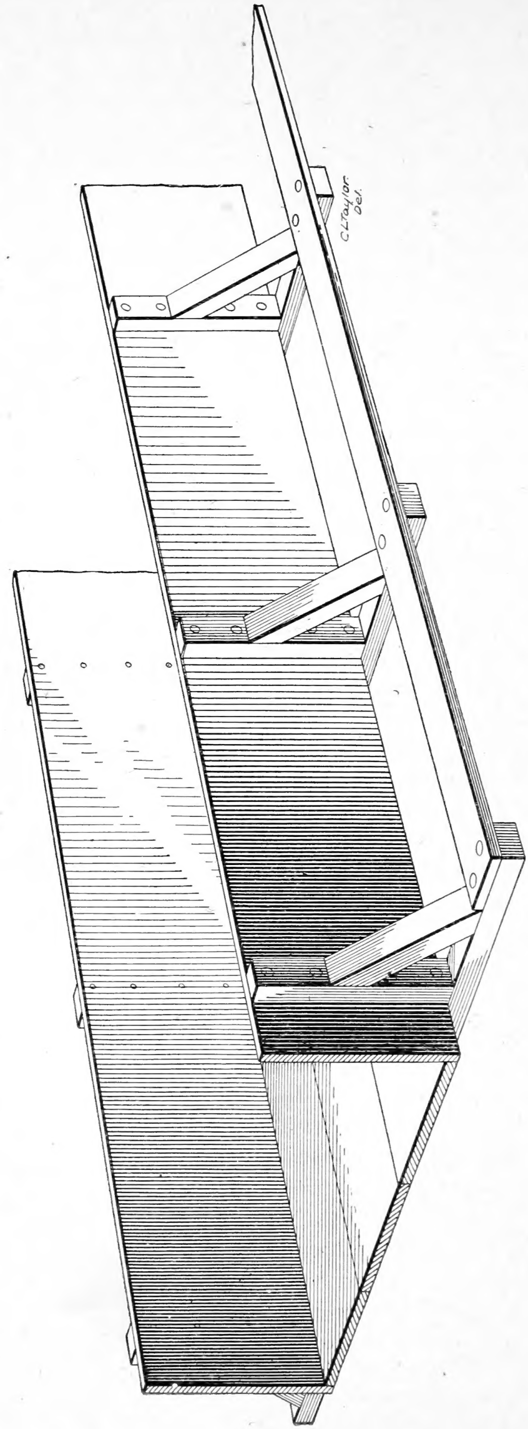


FIG. 1.—Common form of box or square flume.

THE WOODEN V-SHAPE FLUME.

The V-shaped flume is at present the type of flume most generally used in the western portion of the United States, and it has given the most general satisfaction for the transportation of manufactured lumber or timber in its different forms of logs, railroad crossties, cordwood, etc. Some of these flumes have been in successful operation for a number of years, and the writer, who has personally examined many of them, has no hesitancy in saying that, if he were to construct a flume, the V-shaped flume is the type he would erect.

Some of the salient points in which the V-shaped flume excels are:

(1) It can be successfully operated with a less volume of water than any other type, since, owing to the V form of construction, the water is always held confined or "compact," and therefore has the greatest carrying power for the amount used.

(2) There is less likelihood of jams forming, since the narrowness of the flume prevents the material from getting partially crosswise and forming a "brace" through the ends, "wedging" or pressing against the sides of the flume. This is a feature especially desirable when handling short material. The narrow formation of the V-shaped flume keeps the timber running "straight," and according as the volume of water in the flume is reduced the formation of the V keeps the water confined in the smallest possible triangle down which the sides of the flume compel the material to travel.

(3) In fluming logs or round timbers the rounded portion of the log settles well down into the V. The water thus confined between the bottom of the stick and the sides of the V constantly tends to lift the log, and this keeps the stick from settling down or rubbing hard against the sides of the flume. In a square flume, on the other hand, the same amount of water could run on both sides of the log and not beneath and would so lose the tendency to "lift" through lack of proper confinement.

Thus if a log or stick of timber is large and heavy, it may sometimes nearly fill the V-shaped flume and occasionally touch both sides. But whenever this occurs the log has the pressure of the full volume of water which the flume can carry backed up behind it to force it along, and the V formation keeps the stick running "straight ahead," so that there is very little opportunity for the water to spread out or run around or get by the stick without taking it along with it. Its transportation is further aided by the uplift of the partially confined water, running around and under it, that is trying to find an outlet or relief from the pressure of the water behind, which must either aid in forcing the stick along or run over the top of the flume.

(4) In cases where it is necessary to have an unusually abrupt descent in some portions of the grade, the V-shaped flume is best adapted to serve as a "slide" or "slip," or "chute," since it is less likely to become jammed, while the material being handled is held by its own weight in proper position in the center of the V. In a great many localities this particular feature of control of the log or stick of timber when it is "coasting" will be found very necessary in handling material from the higher mountain slopes, especially in places where it is impossible to maintain a steady and equable grade from the top to the bottom of the mountain without too great expense, and where it may be necessary to have a form of construction that will carry logs or timber safely for a long distance when the grade is so abrupt that it is impossible to maintain a sufficient volume of water in the flume to prevent the material from rubbing or sliding along on the sides and bottom. In such localities and under such conditions the V-shaped flume, when strongly constructed so as to combine both the objects of flume and chute, has been and will be found altogether the most desirable.

DEGREE OF ANGLE FOR "V"-SHAPED FLUME BOXES.

In the construction of the sections or "boxes" in V-shaped flumes a number of different degrees of angles have been used in the past. In some instances the constructors have used an angle as low as 70 degrees, while others have constructed flumes with an angle of 110 degrees. The results of experience and the consensus of opinion, however, are that the 90-degree or straight right angle is the most satisfactory form of V-box construction for all purposes, and this is the degree of angle that is referred to when speaking of V-shaped flumes in this bulletin unless otherwise specifically stated.

METHODS OF CONSTRUCTING THE "V"-SHAPED FLUME.

There are many different methods and styles of construction used in building V-shaped flumes, varying according to the kind of material to be handled. In some cases the brackets or frames that support the sides of the V are made from round pole wood simply flattened on one side so as to give an even surfaced support to the boards forming the "lining" or inside of the V, while the sills, stringers, braces, and trestling may be constructed from small round timber or poles, leaving only the lining or inside of the box to be constructed from sawed lumber. The form of construction of the different sections of the flume, or, as they are called, "boxes," also varies in length from short ones of 6 feet up to those of 20 feet. In the construction of the lining or inside of the boxes, lumber of variable thickness and width is used. The boxes are sometimes made of only one thickness of boards simply joined together, but more commonly the lining of boxes is constructed with two thicknesses of boards with the joints broken by varying the width of the boards, as shown in figure 2. Another form of box construction is by the use of a single thickness of boards with "battens" to cover the joints, the battens being spiked over the joints on the outside in the sections between the brackets or arms, as shown in figure 3. There is still another form of box construction in which the battens are continuous. (See fig. 4.) In such cases the battens are "cut in" or set into the arms or brackets on the outside of the V, thus making a continuous "broken joint."

There are certain individual advantages in each of these different styles of box construction, and the right one to use is a question which the prospective operator must always determine for himself. The use of the continuous battening running under the arms requires some cutting into the bracket frames or arms in order to let the battens pass through them, and consequently, to a certain extent, weakens the arms. This usually necessitates a heavier arm than would be required if the battens only reached from one arm to another and were spiked over the joint entirely independent of the "arm." On the other hand, the continuous battens are held firmly in place by the arms and braces, and it is almost impossible for battens properly put on in this manner to get out of place while the arms and braces are firmly in position.

The use of the double-lined box with joints broken is contended for by some operators on the ground that it is always necessary to replace the lining of the boxes occasionally on curves and in places where the passage of lumber wears most rapidly. It is also contended that the doubled box retains moisture much better between the two linings and, therefore, will permit of the flume standing idle without any water running in it, for repairs or other reasons, for a much longer period of time without the boxes becoming thoroughly dried out and "checking" so that the flume will leak, or warping out of shape and position, or drawing the nails used to hold the lining in place. The battening between the different arms or frames makes it possible to use almost any width or thickness of material for this purpose. It can be put on or taken off without interfering with any of the other forms of construction, and this feature also has its ardent supporters.

TRIANGULAR BLOCKS IN THE BOTTOM OF THE "V."

In some instances it has been thought advisable to fill the bottom of the V in a flume with a triangular section of wood sawed in such form that it would fit snugly into the bottom of the V on the inside. Some constructors claim that this block serves the twofold purpose of reducing the amount of water necessary in operating a flume and also strengthens the flume itself. It is not believed, however, that the benefit to be derived from this form of construction is sufficient to compensate for the increased cost of construction and the greater

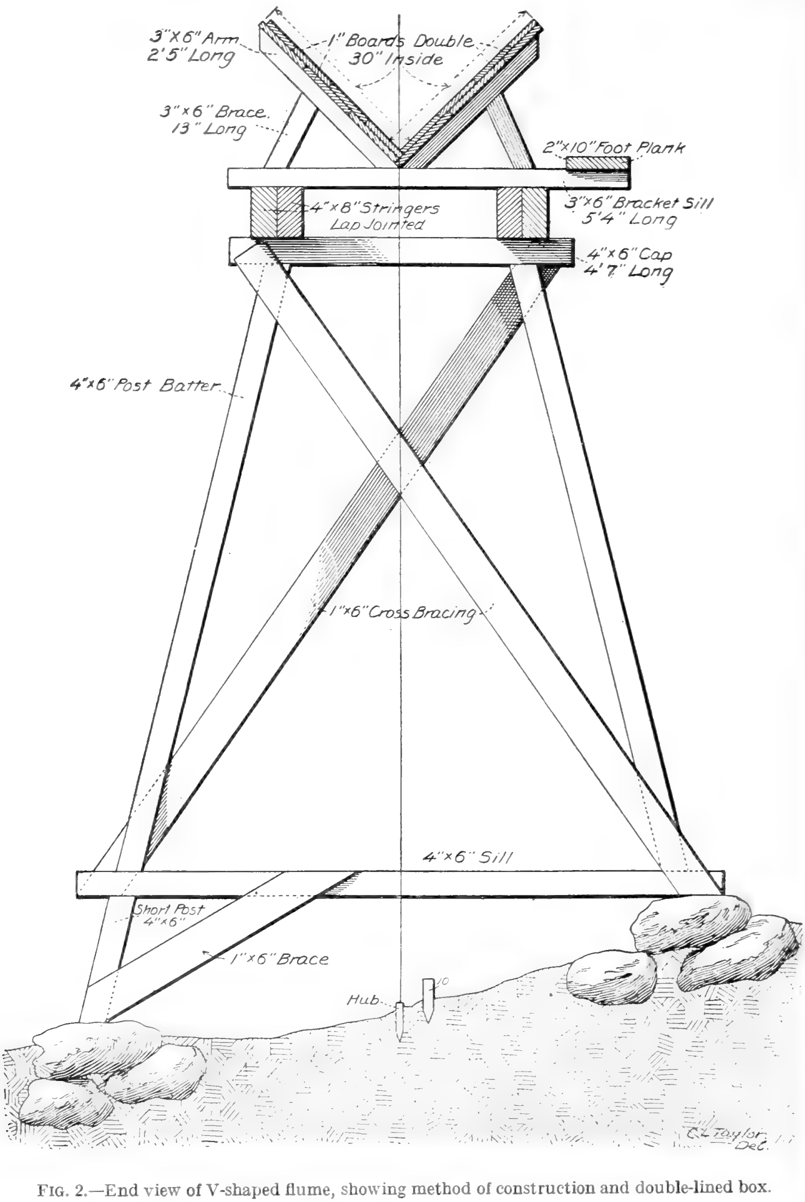


FIG. 2.—End view of V-shaped flume, showing method of construction and double-lined box.

amount of material necessary. The prospective constructor should be governed by the location, kind of material available for construction, duration of life of flume desired, and material to be handled in deciding what type of construction he will adopt.

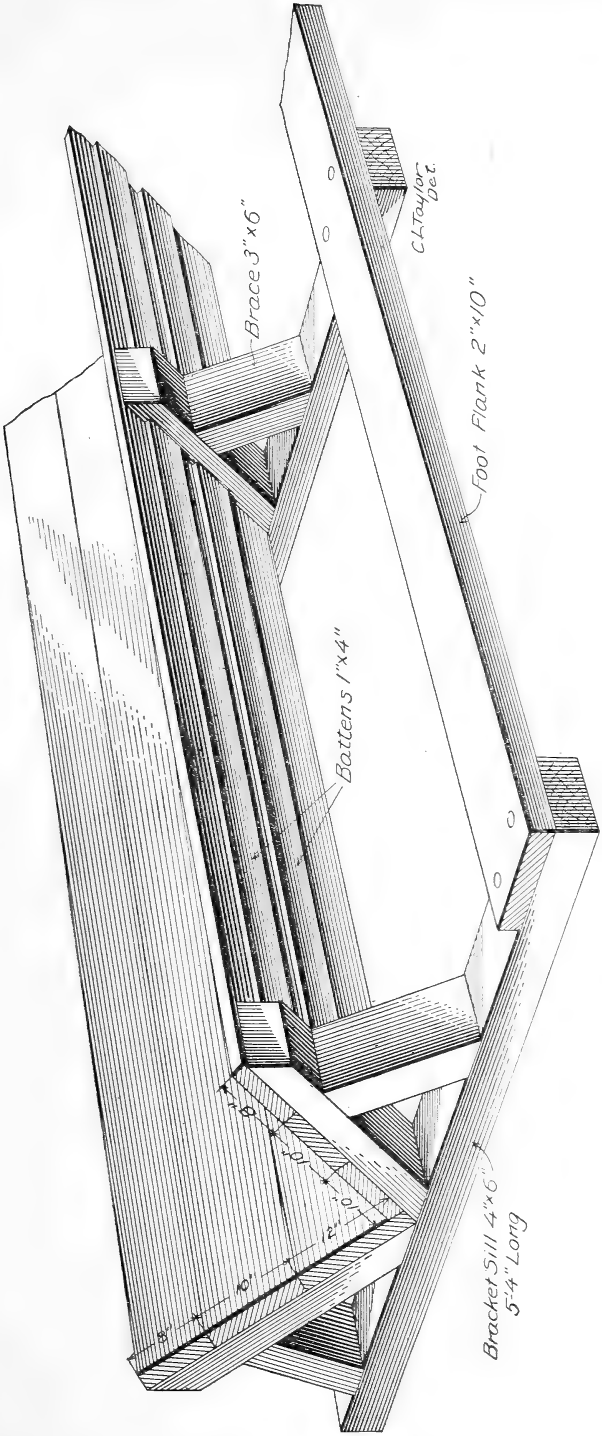


Fig. 3.—View of flume showing dimensions of different parts.

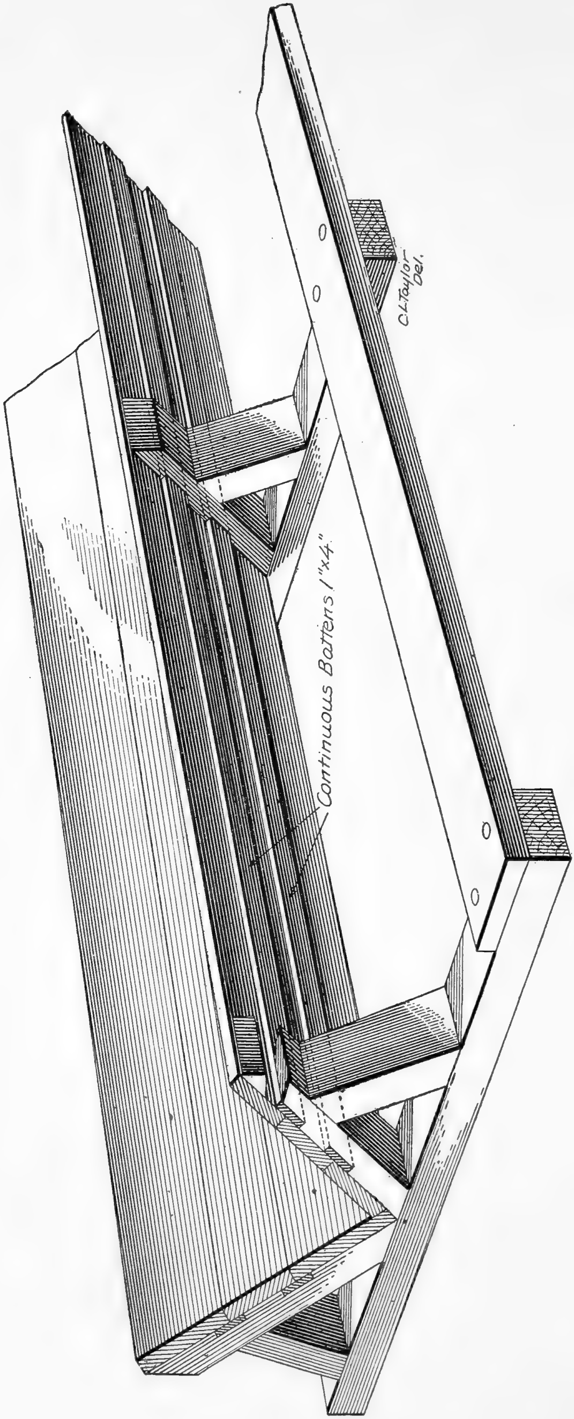


Fig. 4.—Side view of a flume constructed with continuous battens.

SIZE OF FLUME.

The kind of material to be handled is a prime factor in determining the size of a flume. If a 30-inch V-shaped flume would satisfactorily handle the material, there would be nothing gained by going to the extra expense of constructing a flume with a V of 48 inches. On the other hand, it is always good policy to construct a flume large enough to carry sufficient water to handle the material desired with certainty and dispatch. For railroad crossties, cants, poles, cordwood, etc., the 30-inch flume is usually large enough, wherever there is a sufficient volume of water available to fill the flume two-thirds full, while for the handling of logs, piling, long timbers, or "brailed" sawed lumber it is usually advisable to have the flume constructed with the sides of the V from 40 to 60 inches in height, according to the volume of water available and the size of the material to be handled. This is also a feature in flume construction in which the prospective operator can save money by not constructing his flume larger or in any more expensive form than is actually needed, since every additional inch in height means the use of more lumber in construction, and is consequently an added and unnecessary cost.

METHODS OF CONSTRUCTION.

For the benefit of those who are entirely unfamiliar with flume construction, a description of some of the salient points may be of interest. It is usually advisable to erect a small sawmill at or near the upper end of a flume location to saw out the lumber needed for construction. This material can be floated down the flume as fast as the latter is constructed to be used for further extension until the whole flume is finally built. This obviates the necessity of hauling the construction material, so far as lumber or timber is concerned, up grade from the nearest point at which it can be secured, and oftentimes cuts out long-distance transportation charges and generally reduces the cost of construction, although it usually necessitates the construction of a passable road for the purpose of hauling the necessary boiler, engine, and sawmill machinery to the upper end of the flume or place where the construction lumber is to be manufactured.

It will be apparent that the nearer this lumber manufacturing point is to the upper end of the flume the more economical will be the construction, as it is much cheaper to float the lumber down the flume to the place where it is to be used in construction than to haul it up grade by teams. Since the flume can usually be filled with water as fast as constructed, where battens are used, there is no great benefit derived from using seasoned lumber for construction purposes, although when a flume is constructed of seasoned lumber the introduction of the water causes the joints to swell and become tighter than where unseasoned lumber is used. The power used for operating the small mill to cut out the necessary timber and lumber to construct a flume is usually the ordinary portable type of boiler and engine, sometimes in the combined form. There will be found cases and localities in which the use of an overshot or an undershot water wheel will more economically furnish the necessary power, where there is an ample supply of water and favorable conditions for its being used for this purpose, and there will be some cases in which electric power to operate the mill, transmitted from a convenient line of some electric-power plant, will be found most economical.

After the mill is installed it is advisable to use prepared frames, "forms," or miter boxes in cutting the brackets, frames, or arms with the "power saw" into the desired length and shape, and also in cutting the braces, stringers, sills, overlays, and material for use in trestling. Experience has demonstrated that the material can be shaped at the mill and transported to the place where it is to be used by means of the water in the flume much more economically than in any other manner. It is advisable to prepare the frames and arms at the mill ready for setting up, and flume them in their finished form down to the point where they are to be used; this method requiring only that they be placed and fastened in position after arriving there. (Fig. 5.)

A CAREFUL SURVEY NECESSARY.

An accurate and careful survey of the proposed line of flume construction is a prime necessity and often a great economy. A needlessly expensive survey should always be avoided, but accuracy of grade and careful and reliable "leveling" is imperative in order to insure lasting flume construction. The equalization of grade is very advisable wherever it can be accomplished without too great an expense. And right here a practical knowledge of the comparative benefits to be derived from having a steady or an even and moderate grade, considered in relation to cost, is of great value. The grading of soil in knolls or hillocks or ridges along the prospective flume line is advisable up to a certain point, if necessary to maintain a reasonably steady grade for the flume. A careful preliminary survey followed by a location survey, using a transit and level, will make it possible to obtain a reliably constructed profile map which will show to the prospective operator what the grading should be at different points of his line. It is always best to know just what the grade is going to be when completed, and approximately what it is going to cost, before starting the construction work. No detailed estimate of the cost of survey is included here, for the reason that the wide range in conditions where flumes might be constructed would make any set figures unreliable and possibly misleading. A

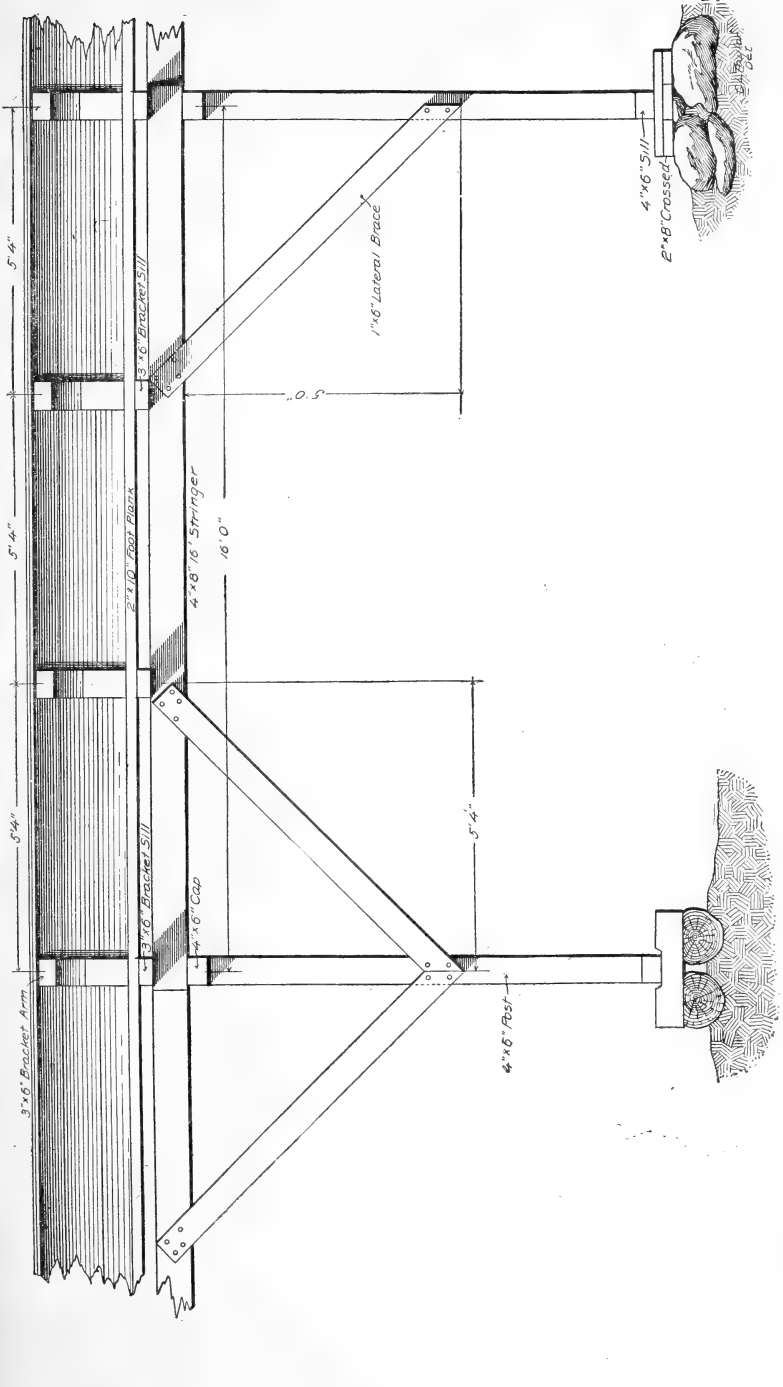


FIG. 5.—Side view of V-shaped flume showing method of construction and lateral bracing.

reliable survey, however, is absolutely necessary, and a carefully constructed profile map highly desirable before construction begins. The cost of the completed survey would be comparable to that of a branch railway location.

The blasting out of rocks and bowlders or projecting points of bluffs is sometimes advisable and necessary in order to reduce curvature and allow the flume to run in as direct a line as possible. This reduces the danger of "jamming" and makes it possible to handle longer material without its "binding" as a result of the ends "pressing" against the lining of the flume on the outside of the curve while the middle of the stick presses against the lining on the inside. Just what is necessary to be done in this respect can best be calculated by using a carefully prepared profile map made from an actual survey of the proposed flume line.

GRADES.

The matter of grade in flume construction is one of great importance. It is not always possible to vary the location so as to maintain an equable or steady, even grade in all portions of a flume line, but wherever it can be accomplished without incurring too great an expense it should always be done. Flume operators have found the question of satisfactory grade to be one of the most important features of successfully fluming material, since where there is a stretch of comparatively flat grade the supply of water may be ample to nearly fill the flume, but upon arrival at a point in the flume line where the descent is very abrupt, the accelerated speed of the water reduces its volume to a small amount in the bottom of the flume and, consequently, results in the flumed material "rubbing" or "sliding" down the descent for a long distance on the sides of the V. Such action wears out the lining very rapidly, necessitates its being frequently renewed, and produces a dangerous condition through the liability of the material to jam and pile up, and either be thrown out of the flume or break it down as a result of the increased weight.

In general, the lowest grade that is considered satisfactory for successful operation is approximately 1 per cent, or 1 foot in 100 feet, but it is better to maintain a grade of from 2 to 5 per cent when possible. The maximum grade that can be used runs up to a very high pitch; some flumes have been successfully operated for a short distance at a grade of 30°, but such a steep grade is very undesirable, as it is usually impossible to maintian a sufficient volume of water in the flume. The most satisfactory results in fluming will be obtained at from 2 to 10 per cent grade, and it should be held below 15 per cent whenever possible.

TRESTLING.

In maintaining the steady or even grade of a flume it is nearly always necessary to do more or less "trestling," in order to avoid unevenness in the line, reduce distance and abrupt curvature, and hold the general grade of the flume at the desired height. (Pl. I.) Here, again, the necessity of a careful survey becomes apparent, for without a knowledge of just what the height of the trestling needs to be in each successive 12 to 16 foot distance, it would be impossible to know just what length the bents and braces of the trestling should be cut, or just what "pitch" should be given to the bracing legs of the trestle, or just where the foundation "stepping" should be placed in order to hold the top of the flume firmly in the desired position.

I can not make the question of the necessity of a careful survey too important, especially for a mountainous or rough and rugged country, which is the type of locality in which considerable trestling is most likely to be used. In this connection, it is sometimes very advisable in the interest of economy, and necessary from the view-point of successful operation, to grade out the earth along the sides of ridges, where this can be done cheaper than trestling can be constructed in other localities along the line, for its effect in maintaining the desired grade. Also, grading out is in some cases desirable in order that the top of the flume, when completed, may be practically on a level or a little below the earth's surface, at least on one side, so that logs or heavy timber to be shipped may be "loaded" into the flume without having to use a needless amount of energy to get them there.

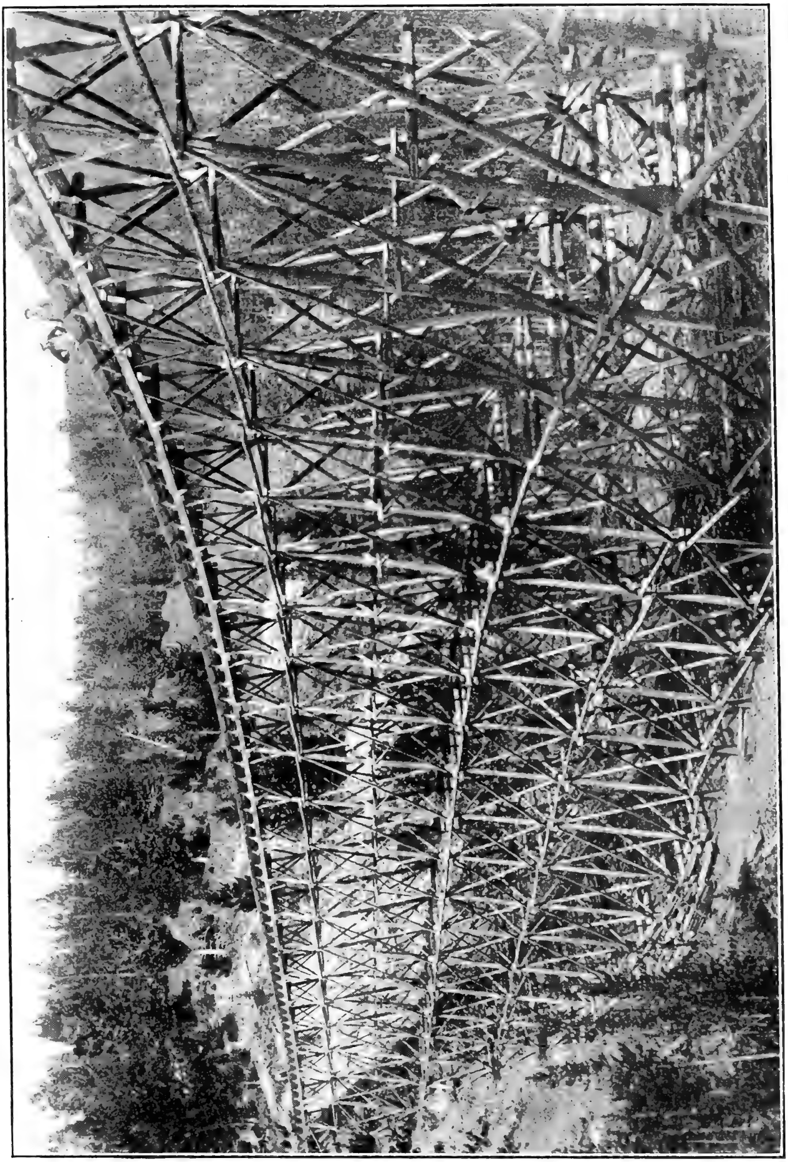
In many cases the amount of money spent in loading hea— terial into a flume set up unnecessarily high above the earth's surface has eventually cost the operator much more than it would to have lowered his flume by grading or slightly changing its course in the first place. This is a feature that should not be overlooked.

CURVES.

In the location of a flume line it is advisable to avoid abrupt curvature as much as possible. Where the contour of the country makes curves or bends in a flume necessary, they should, whenever possible, be on long, even lines. (See Pl. II.) A sharp curve in a flume throws the weight of the material and the water by centrifugal force to the outside of the curve, and the abrupt bend in the flume has a tendency to dam up or hold back the water. The material is thus much more liable to jam or block on an abrupt curve than on a gradual one. When a jam occurs in the flume the blocked material acts as a dam, and after several sticks or pieces of lumber have stopped, the front end of the block or jam rests solidly on the sides and bottom of the flume. In consequence the water is forced over the sides, and usually throws the material out of the flume, especially if the curve is on an abrupt descent, or else the constantly increasing weight of the jam breaks the legs of the trestle, if there be one at this point, or perhaps causes the whole framework to collapse. It is then often a matter of considerable loss of time and expense before the flume is repaired and again ready for operation. The degree of curvature should be kept as low as practicable, and should rarely be permitted to exceed 20°.

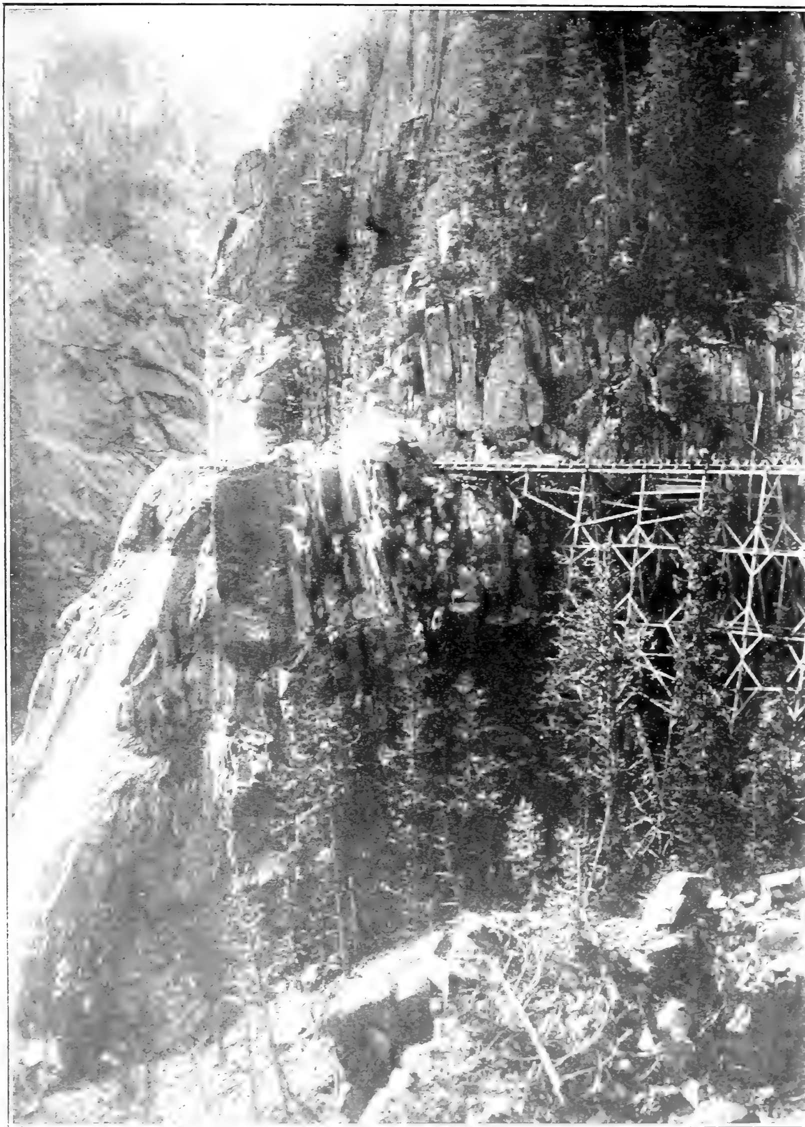
The length of material to be transported is an important factor in deciding the degree of curve that can be used, since very long material can not be successfully transported in a flume having a very abrupt curve. The curve would have to be sufficiently open to allow the chord of curve to be represented by the length of the longest material desired to be handled, with a small allowance for clearance. No curves should be used in construction that will cause the material to "bind." The longer the material the less abrupt curvature is permissible, and vice versa. The bracing of a flume on the outside of the curve necessarily should be more rigid and stronger than on the inside, since the greater pressure "thrust" or "throw" of the water and material being shipped is toward the outside of the curve. Very abrupt curves require increased bracing and the placing of the arms and brackets at shorter intervals, in order to hold the flume in its proper position.

Shorter "boxes" and closer spacing of "bents," "arms," and "braces" on curves.—Where the topographic conditions in a locality are such that it becomes absolutely necessary to have abrupt curves in a flume, it is advisable to reduce the length of the boxes and correspondingly shorten the distance that the "bents," "arms," and "braces" are placed apart, for the twofold purpose of evening up or reducing the sharpness of the angles in the joining of the boxes on the curve, and also to give more stability and strength to the flume at the points where there will be the greatest strain upon it. It will be apparent that long boxes in a flume at a point where there was an abrupt degree of curvature would necessitate sharper changes in direction than would shorter boxes, thus producing something in the nature of square corners. These corners, particularly if there were a rapid descent in the flume line at such curve, would have an effect something in the nature of a dam or stoppage in the flume, and as a result cause the water to slop over or run out over the sides. In addition, all material coming down the flume, as a result of the quick change in the direction of its course, would "strike" sharply against the outside "corner," and the continual pounding of the material against the side of the flume would be very likely to jar and eventually loosen up the joints at this point, throw the flume out of alignment,



A FLUME TRESTLE 775 FEET LONG AND 75 FEET HIGH CONSTRUCTED OF ROUND MATERIAL.

Only the stringers and boxes are made of sawed lumber.



AN UNAVOIDABLE, ABRUPT CURVE.

When material is thrown from a flume at such a point as this it is practically a loss. Note the men raising the sides of the "V." Trestle is constructed of sawed material.

FIG. 1.—A BRANCH FLUME, SHOWING METHOD OF CONNECTION WITH MAIN FLUME.

In this case the branch is closed off by the use of two "lining" blanks.

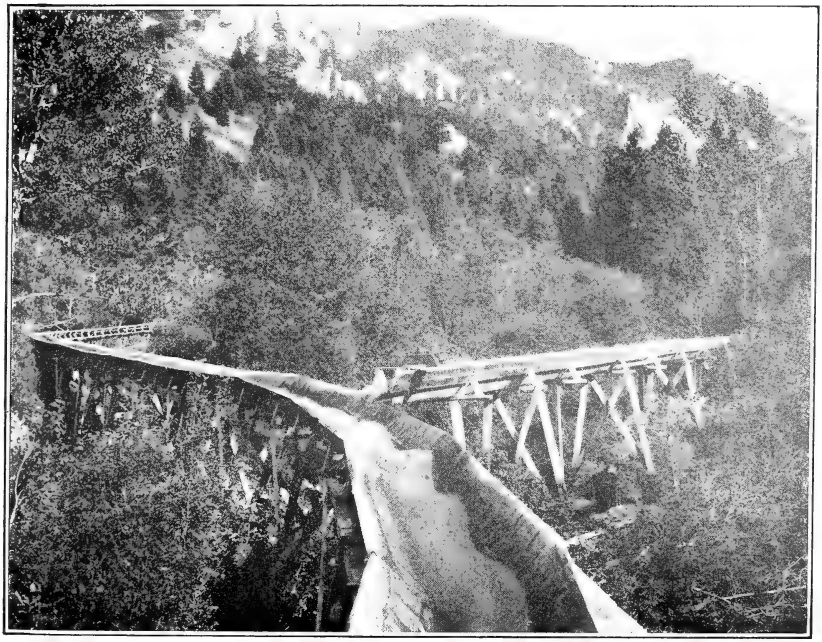
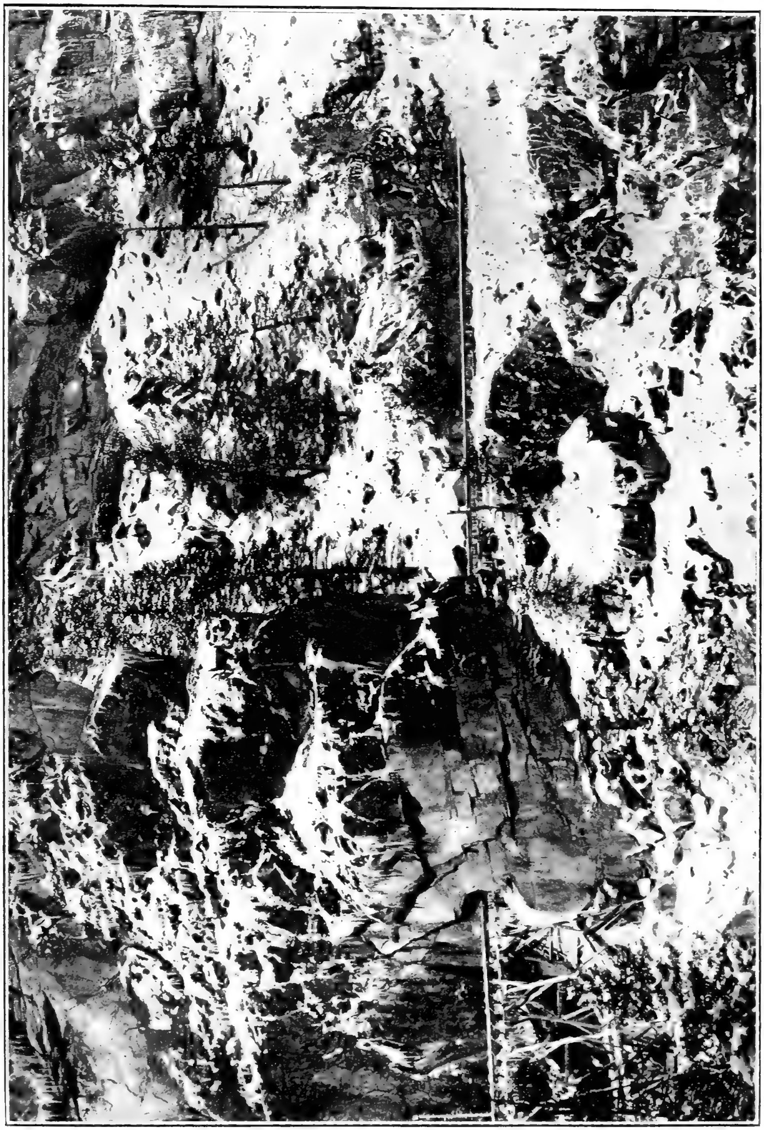


FIG. 2.—A FEEDER FROM A SIDE CREEK.

Notice cheap form of construction.



A TUNNEL THROUGH A LEDGE TO AVOID CURVATURE.

In this case it was cheaper to tunnel than to blow out the entire ledge.

and cause it to leak badly, or at least batter and wear it out more rapidly than would be the case if the curve were more gradual. More than this, there is always the increased danger of jams or blocks occurring in the flume at such points. It is for this reason that shorter boxes, which will more evenly graduate the curve, are desirable.

There are no hard and fast rules that will correctly fit any and all conditions, but in general on curves of from 6 to 10 degrees, the boxes in a V-shaped flume should be "jointed" at least once in every 12 feet with corresponding spacing of bents and reinforced bracing. On curves exceeding 10° and less than 15° the box should be jointed at least once in every 8 feet of length, and on curves of more than 15° boxes should be jointed at least every 6 feet, with corresponding spacing of bents and reinforced bracing in every case.

As said before, but repeated now for the sake of emphasis, whenever it is possible without incurring too great or prohibitory expense, very abrupt curvature should be avoided in flume construction, and it will usually be found a wise policy to go to a considerable additional expense in excavation work or blasting out of rocks and ledges in order to reduce curvature to a satisfactory degree. In every case where extreme curvature is unavoidable the foundation footings upon which the flume is supported should be carefully placed on very solid material, in order to withstand the continued impact and jar of the logs striking the sides of the flume; and the entire flume construction should be strongly reinforced at such points, not only by shortening the length of the boxes and placing the bents, side arms, and braces closer together, but also, if trestling is necessary at such points, by strongly reinforcing the trestle bracing, both "lateral" and "sway."

Increase in height of sides of "V" on abrupt curves.—It is advisable on abrupt curves to increase or raise the height of the V on the outside of the curve, in order to cause the material being shipped to drop back into the flume when it tries to "climb," as it always does in such places, and thus prevent it getting on top of the side of the flume and "riding" until it strikes some little projection or joint and forms a "block" or "jam." (See Pl. II.) On very sharp curves it is usually advisable to raise both sides of the flume a little higher than is necessary on tangents and on equable grades, in order to retain the water in the flume, especially if there be a very abrupt descent at the point of curvature, as is sometimes unavoidably the case. The raising of the sides necessitates only the use of a longer arm and additional height of the lining of the flume at such points.

FEEDERS.

Feeders constructed at various points along a flume line are usually necessary in order to maintain the requisite amount of water and to furnish a sufficient volume to operate a flume successfully on the different grades. A volume of water that would be ample to handle or float the material satisfactorily on a long stretch of flat grade might not be sufficient to furnish an adequate volume to prevent the material from rubbing or striking on the bottom in a section of the flume where the descent was more rapid; and it is also usually necessary to have feeders coming in at different points along the line in order to replace the water that has been lost as the result of leakage or slopping at the abrupt curves. The side feeders are usually brought in from small side creeks by means of a short line of V or square flume constructed from a small dam made in a side creek at some point where there is sufficient descent to carry the water down into the main flume. (See Pl. III, fig. 2.) The number of feeders, the distance apart, and the points where they shall be brought in are determined by the necessities of each case.

Where a main flume line is following closely the bed of a creek having considerable drop, it is usually advisable to take the water from the creek itself by means of a feeder flume having a slight down grade until it intersects the main flume. This can be done by blocking up under the feeder flume, either by trestles or by any other economical and convenient form of foundation, until its end will reach the top of the V. It is usually advisable to make the feeder line as direct as possible and thus avoid increased construction. Feeder flumes do not have to be as substantially constructed as the main flume lines, since nothing except water is conducted in them, nor is the form of construction as important for the same reason. Therefore the single-thickness square-box type of flume is often used for this purpose. Any method of blocking in under a feeder flume that will furnish a substantial foundation is permissible. Here again, however, as in the trestling under the main timber or lumber flume, too cheap construction, trestling, or blocking is false economy, as the work should always be stable enough to be lasting.

TUNNELING.

Tunneling through such obstacles as sharp ridges or projecting bluffs has sometimes been found advisable, economical, and necessary in order to maintain a proper and desirable grade, shorten distance, and prevent too abrupt curvature. It is sometimes cheaper to tunnel for a *short* distance through an obstruction than to trestle for a *long* distance in order to raise the line over it or to put in a long curve to get around it. It is also sometimes cheaper to tunnel through a ridge or projecting point of rocks than it is to make an open cut. This has been demonstrated by the practical experience of a number of operators. (See Pl. IV.) A tunnel should be carefully located by survey, so as to be certain that it will be very close to the desired grade in order to reduce the amount of necessary excavation to the minimum. This will permit of the "stringers" for the flume resting on solid foundation in the bottom of the tunnel, which, once solidly placed, usually requires little or no repair.

There is no danger of flumes constructed through tunnels being filled as a result of snowstorms nor affected by contraction or warping as a result of the sun's rays. The principal danger resulting from construction through tunnels is that of material falling into the flume from the top of the tunnel, unless it is protected, when the tunnel is through loose earth, by framework and lagging over the top of the flume. This danger, of course, does not exist where a tunnel is driven through solid rock, as the rock itself furnishes a stable roofing. And if the earth through which the tunnel is driven is solid, it is not always necessary to go to the expense of setting up frames and placing "lagging" over the top of the flume, since what small amount of loose earth does drop into the flume as a rule will quickly be dissolved and washed away by the running water. It is usually possible, by varying the flume-line location, to get around obstacles without going to the expense of driving a tunnel through rocks and ridges, but there will be found cases in which it is impossible to secure a satisfactory location and at the same time maintain a desirable grade and avoid very abrupt curves without resorting to tunneling.

SMALL HOLDING RESERVOIRS AT DIFFERENT POINTS OF FLUME.

It is sometimes advisable to have small holding reservoirs or "catch basins" constructed at different points along a flume line, where it can be done without involving prohibitive expense, in order to provide an additional storage place for logs, crossties, or rough lumber. The upper end of a flume may have to be used to its fullest capacity for a short time in the spring, when the melting snow and early spring rains will furnish a sufficient volume of water to transport material down to the upper end and past more abrupt portions of the flume, and sometimes when this rapid shipment is going on, loading or storage facilities at the lower end of the flume may become so congested that it is impossible to take care of all the material, even temporarily, at that end.

Under such conditions it is sometimes possible to construct at different points along the line of the flume small storage reservoirs, which can be cheaply formed by damming up some small stream or using some small natural pond favorably located along the line, thus diverting the class of material not desired to be handled clear through at once into such reservoir, and taking it out and shipping it later with the aid of the increased volume of water available at this lower point of the flume. The prospective operator must always be his own judge of whether this is necessary and desirable, and should properly take into consideration the possibilities of such features being needed when locating the general line along which his flume is to be constructed.

Where such features are carefully looked up before the final location of a flume line is settled and flume construction has begun, it is sometimes possible slightly to vary the location of the proposed flume line so as to bring it to the desired grade to be successfully operated in connection with a cheaply constructed holding reservoir, without in any way decreasing the transporting capacity of the flume. It is also sometimes advisable to construct a small reservoir or "catch basin" at the foot of an unavoidably long and very abrupt grade, so that when the material being shipped leaves the flume or slip it will strike into a pond of water and thus avoid being split or broomed. Sometimes the reservoir and its additional feeders will furnish enough water to permit the flume line to be carried on an even grade from the point of the "catch basin" or small reservoir at the foot of an abrupt descent to its destination. In such cases the reservoir and feeders act as equalizers of the volume of water in the flume.

It has been found necessary in some instances to have small storage reservoirs, provided with a small gate that could be quickly closed or opened, located at different portions of a flume where no feeders were available, in order to obtain a sufficient volume of water to carry the material being handled to the next station or reservoir, or to its destination. Where conditions obtain that make this kind of an operation necessary, it is usually advisable to have the mouth of the "intake" considerably wider than the flume, which permits the water to go into the flume opening in a wide unobstructed flow.

When operating under such conditions it is always advisable to let the water in the flume run for a short time before any material is shipped. Otherwise the material receives a strongly accelerated movement on the rapid descents, and is therefore carried by its own weight and momentum into the slower moving volume of water in the flat grades at a greater rate of speed than the water is moving, and consequently runs slightly faster than the water. For this reason the water should always be allowed to run in the flume for a sufficient time to be sure that the latter will be filled its whole length, or at least to the next station below, before any material is started on its way from the shipping point above.

RESERVOIR PONDS AT HEAD OF FLUMES.

It is advisable and oftentimes necessary to make a small artificial pond or reservoir at the upper end of a flume in which to "land" or "bank" the material to be shipped, especially when handling logs, railroad crossties, or heavy unmanufactured material of any kind. Conditions sometimes make it possible to use the ice on a pond of this character at the head of a flume as a banking ground in the winter or a place to land and hold the material to be transported by the flume in the spring during the time when the cold weather and ice prevent the flume's use.

When a pond is being used for this purpose, if there is more than one kind of material being put on the pond, it is usually advisable to place substantial booms on the ice between the different classes, so as to keep them from getting mixed when the ice in the pond thaws out, and further to enable the different classes of material to be shipped according to the desires of the operator or the needs of the manufacturing plant, if there be one located at the lower end of the flume. If the depth of the pond is sufficient, it is usually more economical to get material into a flume from where it is landed on the pond, which requires only the separating or "breaking down" of the different piles or skidways, than it is to get material into the flume when piled alongside. In the latter case some of it will usually be at a distance from the flume, thus necessitating either its being loaded onto a dray or carried by hand and dumped in. It is much more economical to float the material into the flume from a reservoir when this is feasible.

Probably the most noteworthy example in the United States of the construction of a storage dam and flume combined is the Aziscohos Dam, on the Magalloway River in Maine. A particularly interesting feature of this construction is an "adjustable intake" to the V-shaped flume, which is so arranged that it can be quickly raised or lowered to suit the varying heights of water in the storage reservoir above the dam. The adjustable flume intake has a range of 25 feet. This flume, which is a wooden V-shaped one built on a large scale, carries the logs from the storage reservoir above the dam down past the rapids below the dam on the Magalloway River to the still water, where they are released from the flume into the river to be floated on down to their destination at the mills on the Androscoggin River. Only enough water to bring the river up to the required driving "pitch," in addition to that which passes through the flume, is released through the "sluice gates."

In July, 1913, this flume was handling logs from 12 to 60 feet in length at the rate of approximately 1,000,000 board feet in 10 hours, with the adjustable intake working satisfactorily at a point 15 feet below the maximum water height. The principle of this construction is applicable to public or private irrigation projects, or wherever it is found necessary to take logs or timbers from a high reservoir dam, having greatly varying heights of water at different seasons of the year, to some more convenient place for manufacture or further transportation, using only the minimum amount of water necessary to get the material to such point.

BRANCH FLUMES.

Material is sometimes brought to the main flume from side gulches, ravines, or small watersheds by the use of what are generally known as "branch flumes." (See Pl. III, fig. 1.) Their use is advisable where there is a side valley with a sufficient volume of water available and containing enough material to make the construction of the branch flume warranted as being the most economical means of getting the material to the main flume. Branch or side-line flumes of this character are usually constructed practically the same as the main flume, except that it is usually advisable, if a mill has been constructed at the upper end of the main flume, to saw the lumber at the already constructed mill and flume it down to the most convenient point of the main flume, where it is taken out and from there hauled by team to the point at which it is to be used in constructing the branch. Unless the branch were a long one, it would hardly justify the erection of a mill for the sole purpose of sawing out sufficient lumber to construct it.

It is sometimes possible to take down a branch flume after the material in a gulch, small creek watershed, or ravine has been cleaned up, and move it to some other point and again set it up for use. Branch flumes are usually brought out and connected up with the main flume, as shown in Plate III, figure 1, so that the material being handled will come out into the latter on a gradual curve on the same level. Branch-flume lines also act as feeders and serve to maintain the volume of water necessary to operate the main flume. It will in some cases be found necessary to use the total volume of water available from two or more streams in order to have sufficient volume to carry the material forward on the lower grades. In such cases it is sometimes possible to bring both the material and water together at the main flume by constructing the branch V flumes very strongly, and using them much as a wet slide is used to slip the material, by the aid of the small amount of water available, from the higher elevations down to where a sufficient amount of water has accumulated to float it to its destination.

SWITCHES AND Y'S.

Switches and Y's are sometimes necessary in the lower end of a flume when it is desired to direct material to different points for piling or to a planing mill, if it be lumber, or to storage places if it be railroad ties, cordwood, or mining stulls, when, as sometimes occurs, the shipping or transportation facilities are not adequate to take care of the amount of material being handled daily by the flume. (See Pl. V.) When this is the case and rough material is to be handled, it is advisable to gradually raise the lower end of the flume on trestles, so as to have the desired space between the flume and the surface of the earth to hold material diverted. Several switches or Y's scatter the material being shipped over whatever area it is designed to use as the storage place until such time as the material is to be manufactured or loaded onto railroad cars for transportation elsewhere. Plate V shows the general idea of the storage Y's.

THE USE OF "SNUBS" IN UNLOADING MATERIAL FROM A FLUME.

The use of a "snub" or temporary block in a flume so constructed that it will act as a dam which fills the flume to its utmost capacity and forces the material that is to be unloaded at this point to float at the highest possible elevation is often very useful in removing the material from the flume, particularly when it is desired to take it out over the side onto a loading platform alongside a railroad track, as shown in Plate VI, figure 1. The form of construction of a snub is shown in figure 6. With short, light material, such as railroad crossties, a snub under certain favorable conditions will throw the product being handled out of the flume without any assistance, although it is always good policy to have a man on hand to be sure that there will be no failure in getting the material out of the flume lest it cause a serious block or jam that may eventually break down the flume, and cause more expense than it would to keep a man on the job all the time. A form of snub working unassisted is shown in Plate VI, figure 2.

REINFORCEMENT OF FLUMES AT POINTS WHERE EXTENSIVE LOADING IS TO BE DONE.

Flume construction should usually be strongly reinforced at those points from which it is contemplated to do extensive shipping or where much material is to be loaded into the flume over the side. The constant pounding of material being dropped or thrown into the flume and striking on the sides of the V has a tendency to loosen the joints unless strengthened, and sometimes to break down the framework. In order to avoid this danger, it is usually advisable to place the bracket arms or frames and their attendant braces at shorter intervals or distances from each other at such points.

Thus, if in the general flume line construction the arms and braces were placed at a distance of 8 feet apart, at the point where heavy logs or timbers are to be put into the flume it would be good policy to at least double the amount of brackets and braces or place them once in every 4 feet. If the timber to be loaded into the flume at this point were unusually heavy, it might be advisable to reduce the distance between the strengthening arms and braces still more. There are some cases where it has been found necessary to have the arms and braces every 2 feet at those points where the greatest amount of heavy material is loaded into the flume (see Pl. VII, fig. 1). It should

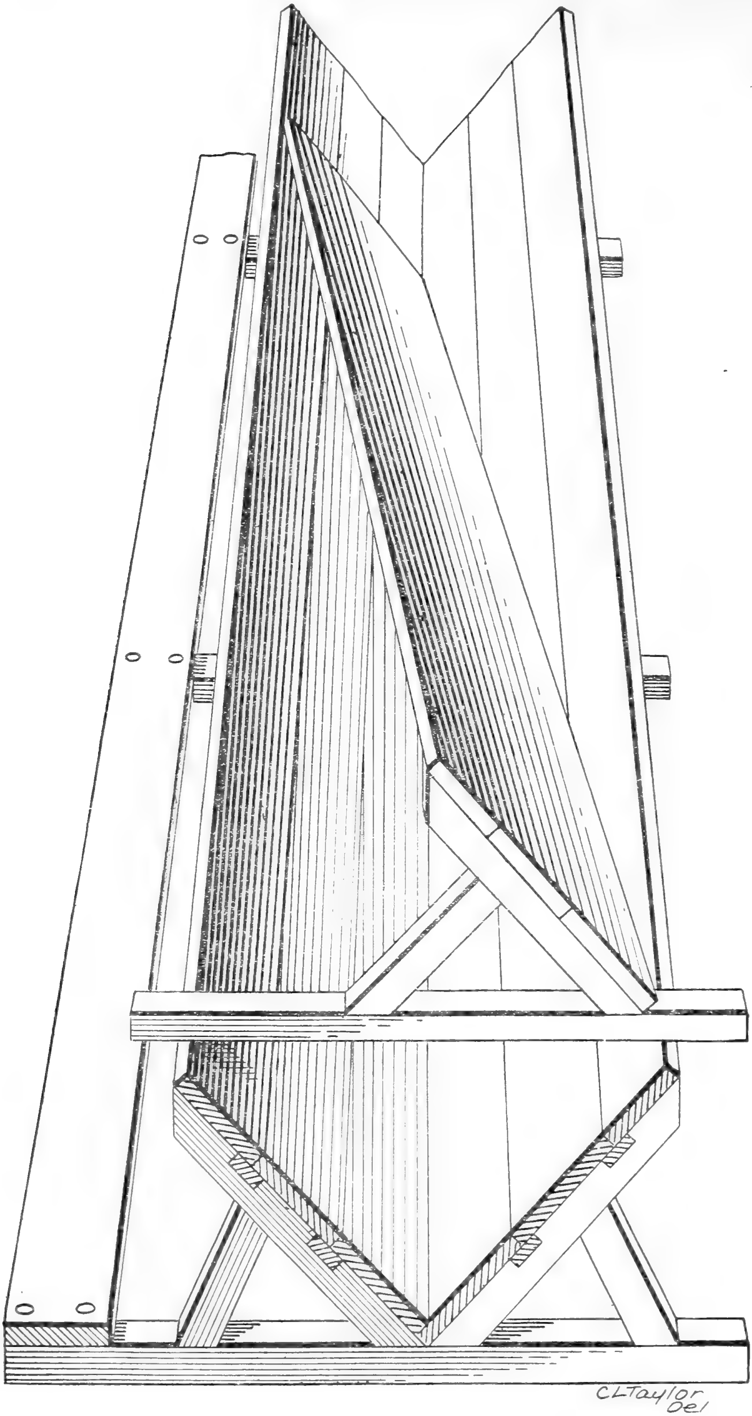
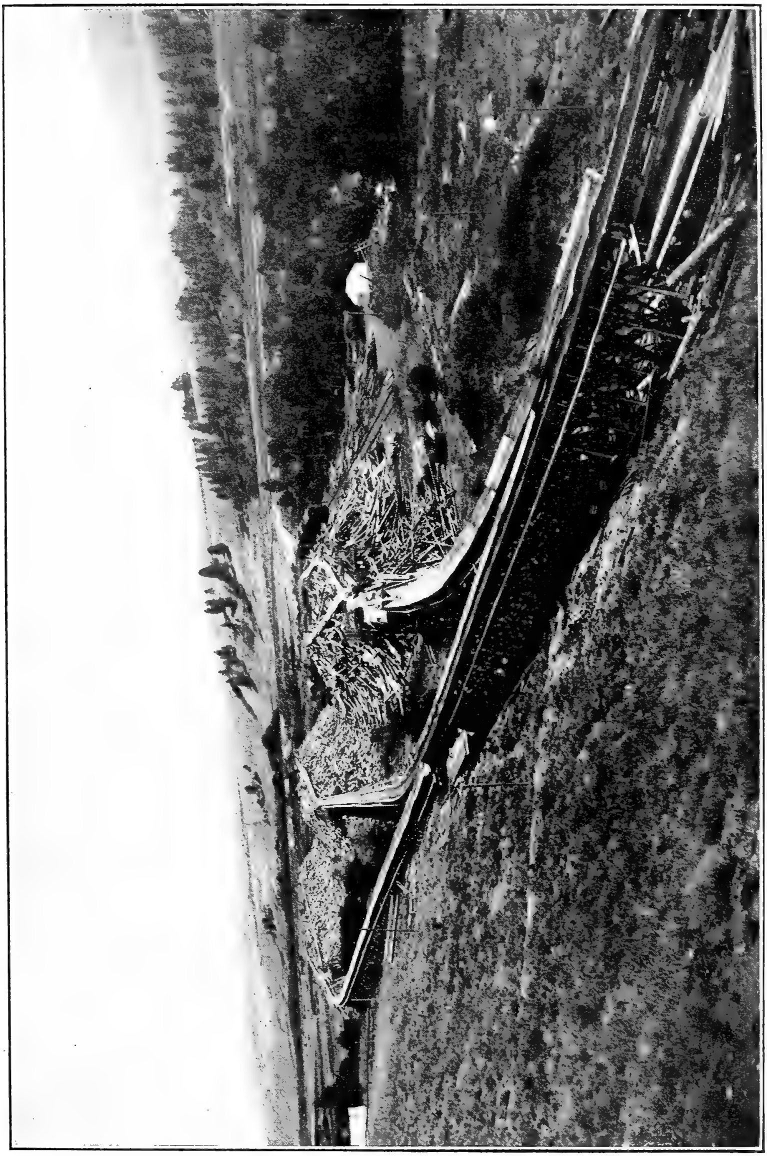


FIG. 6.—A "snub" in position for throwing small material out of a flume.



"Y'S" OR SWITCHES AT LOWER END OF A FLUME, SHOWING METHOD OF UNLOADING MATERIAL FROM THE FLUME AT SEVERAL POINTS SO AS TO CAUSE NO INTERFERENCE WITH LOADING OPERATIONS.

In this case the main flume can be switched or thrown quickly from one "Y" to another.

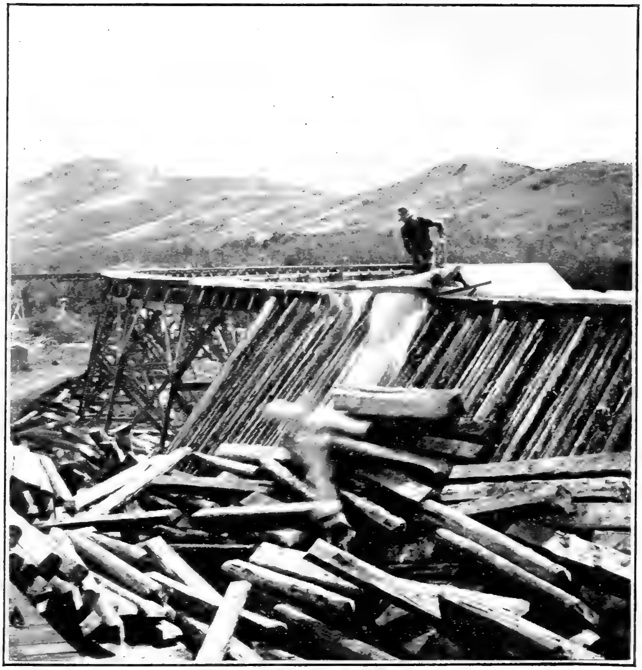


FIG. 1.—A "SNUB" IN OPERATION, THROWING CROSSTIES OUT OF FLUME AT RAILROAD LANDING BY PRESSURE OF WATER.

Man present to prevent material jamming.

FIG. 2.—A "SNUB" WORKING ALONE.

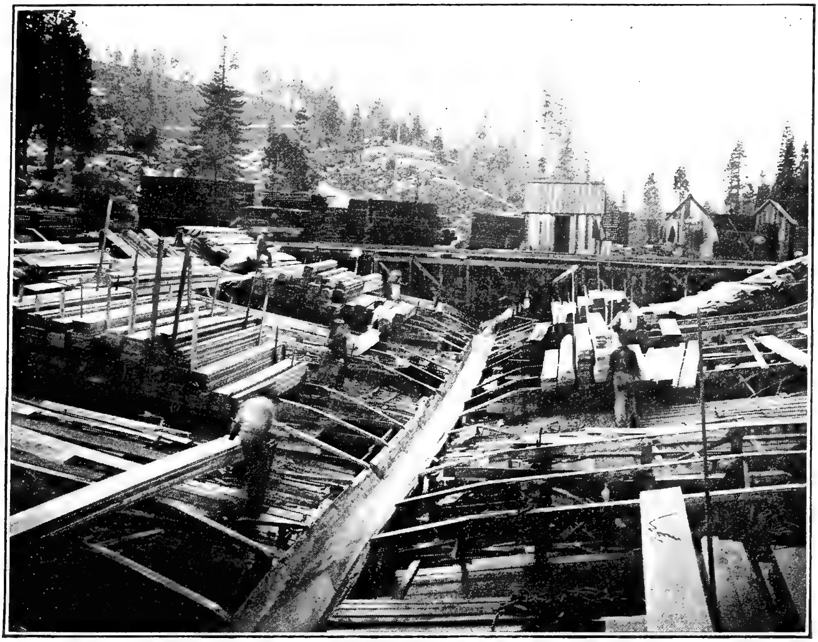


FIG. 1.—BRAILING AND ACCOUTRING LUMBER AT THE UPPER END OF A FLUME.

Note the sloping "ways" on which the brails are slid into the flume after being clamped.

FIG. 2.—A "MINING STULL" DUMP AT THE LOWER END OF A FLUME WHERE THE STULLS ARE RUN DIRECTLY OUT OF THE "VENT" ENDS.

Note the several "vents" and the railroad spur tracks between the different flume "Y's."

FIG. 1.—A FLUME IN THE CONSTRUCTION OF WHICH SMALL ROUND TIMBER WAS USED FOR EVERYTHING EXCEPT THE "BOX."

FIG. 2.—CRUDE FORM OF FLUME CONSTRUCTION WHERE ONLY THE LINING IS OF SAWED LUMBER, THE REMAINDER BEING CONSTRUCTED OF SMALL ROUND TIMBER AND POLES.

be understood, however, that the necessity for stronger bracing at different points of the flume depends largely, if not entirely, on the class of material being handled, and the prospective operator should be guided by this factor.

TELEPHONES A VALUABLE ADJUNCT TO FLUME OPERATION.

The use of the telephone in connection with fluming operations has been found a very necessary and valuable adjunct by its assistance to the operator in a great many ways. By its use it is possible to know just what is going on at the different points along the flume where "stations" are maintained, and notification of a serious jam or break in the flume can be quickly transmitted to the head of the flume and the shipping of material stopped. Otherwise it might be continued for a considerable length of time or until it was possible to get word to the upper end of the flume, and before this could be accomplished and the shipping stopped the break or block might become of such magnitude that to get the material back and repair the flume would cost almost as much as installing a telephone system. Telephone wires have sometimes been strung along and attached to the sides of flume construction, but this method is not considered generally satisfactory, as there is always the danger that when the flume becomes jammed or is broken down the line may also be put out of commission at the very time when its assistance is most needed. It is generally more advisable to have the telephone wire strung on independent poles or convenient trees where the line runs through a forest than to have it attached to the framework or sides of the flume.

By the use of the telephone it is possible to notify the shipper at the upper end of the flume what class of material to ship, when to ship it, and to keep in touch with what is going on along the flume line at all times. If there be a mill operating at the upper end of the flume, it is often very important that the employees at both ends of the line know exactly what class of material is going to be handled, since for a certain length of time one class might be going to a railroad landing to be loaded onto cars for shipment, after which for the remainder of the day a class of material might be shipped that should be turned by a switch into the storage pile, or vice versa. The valuable aid in fluming operations obtained through the use of the telephone usually makes its installation as an integral part of the plant most advisable.

SAWED MATERIAL FOR STRINGERS, SILLS, BRACES, ETC., NOT A NECESSITY BUT USUALLY MORE ECONOMICAL.

It is not actually necessary that the material used in flume construction, with the exception of the lumber for the "box" or body of the flume, should all be sawed. A number of flumes have been constructed and successfully operated where the only sawed lumber used was that for the box, the trestling, sills, crosspieces, stringers, arms, and braces all being made from round poles flattened so as to fit solidly in the construction work. This method of construction is, however, often more expensive than to use the sawed material, where the latter can be economically obtained and cut into proper lengths by a power saw.

The use of poles or small round material usually makes it necessary to cut the braces, arms, etc., into the desired length and form by hand power, and the increased cost of the manual labor necessary in such cases usually more than counterbalances the expense of having the material sawed at a mill, when this can be done without prohibitory expense. Existing conditions should always decide what method of construction will be most advisable. Illustrations of flumes where only the "box" was constructed of sawed lumber are shown in Plate VIII.

WATER USED IN FLUMING SOMETIMES AVAILABLE FOR IRRIGATION PURPOSES.

In some localities in the western country where irrigation is necessary, it will be found possible to utilize the water brought out from the mountains by the aid of a flume for irrigation purposes after it has served its purpose as the transporting medium for logs, timber, or lumber.

Where there is a possibility of using the water for irrigation, it may be found advisable to construct a flume on a larger scale than is absolutely necessary for the simple transportation of the lumber and timber, in order to increase the amount of water available for irrigation purposes. This is a feature that should be carefully considered by the prospective operator when local conditions are such that a combination of the two different uses of the water can be made remunerative.

BRAILING AND ACCOUTRING LUMBER.

Where sawed lumber is being shipped for a long distance in a flume, it has in some cases been found advisable to brail or clamp a number of the boards, planks, or other material together, in order to make a compact body and thus reduce to a minimum the danger of forming jams and injuring the material being transported. It has also been found advisable to accoutre or hitch several of the "brails" together, by the use of short sections of shingle twine, wire, or other form of attachment, between the different clamped or brailed blocks of sawed lumber. In practice it is customary to pile from 10 to 20 boards or planks, usually aggregating about 200 feet, in a block at the mill or point where the shipping is being done. The size of the brail depends on the size of the flume and the class of material being shipped.

A metal clamp of the general form, shown in figure 7, is then slipped over the ends of the brail, and a dry wooden wedge, which can be quickly and cheaply constructed by the use of power saw in the mill, is driven into the end of the brail between the boards or planks, thereby forcing the lumber up against the teeth on the clamp and holding the whole body firmly in the position in which it was placed before being clamped. The twine is attached to the iron clamps on the front and rear ends of the respective brails to be shipped, and when a sufficient number have been prepared they are released in the flume, the weight and momentum of each one tending to keep its fellow, to which it is attached, following it in proper position, and preventing each one from running alongside the other and wedging or piling on the curve. The weight and momentum of the forward brail has a tendency to pull the following brail into line and thus maintain the average momentum of the whole body. This principle can be applied to sawed timbers, using staples and rope or wire to hold them in proper position. Several brails are usually accoutred together by the use of the tarred rope, shingle twine, wire, or other means of attachment.

Upon arrival at the lower end of the flume the wedges are withdrawn, the lumber is released from the brail, and the "clamps" are hauled back to the head of the flume to be used again. This method of consolidating the shipments has been found particularly advisable for use on long, comparatively flat grade flumes, as it reduces very materially the amount of supervision or number of flume walkers necessary to keep the material running from what would be required if it were shipped separately, and prevents the timber from being split, broken, and battered on the ends or otherwise injured as much as when shipped in "loose" board form. Figure 7 shows the method most commonly used in brailing and accoutring material, and a form of clamp.

PLANING MILLS SHOULD BE LOCATED AT LOWER END OF FLUME.

As a general proposition the planing of sawed lumber which it is necessary to transport in a flume should be done only after the fluming process is completed, since fluming lumber after it is planed usually results in more or less discoloration of the surface, which is also liable to be marred in transit, thus injuring its sale value.

SIZE AND CARRYING CAPACITY OF FLUMES FOR DIFFERENT CLASSES OF MATERIAL.

The most advisable size of a flume for successfully transporting different classes of material depends on such factors as the grade, volume of water available, length of flume, etc. The class of material to be handled is always the principal factor to be considered, and

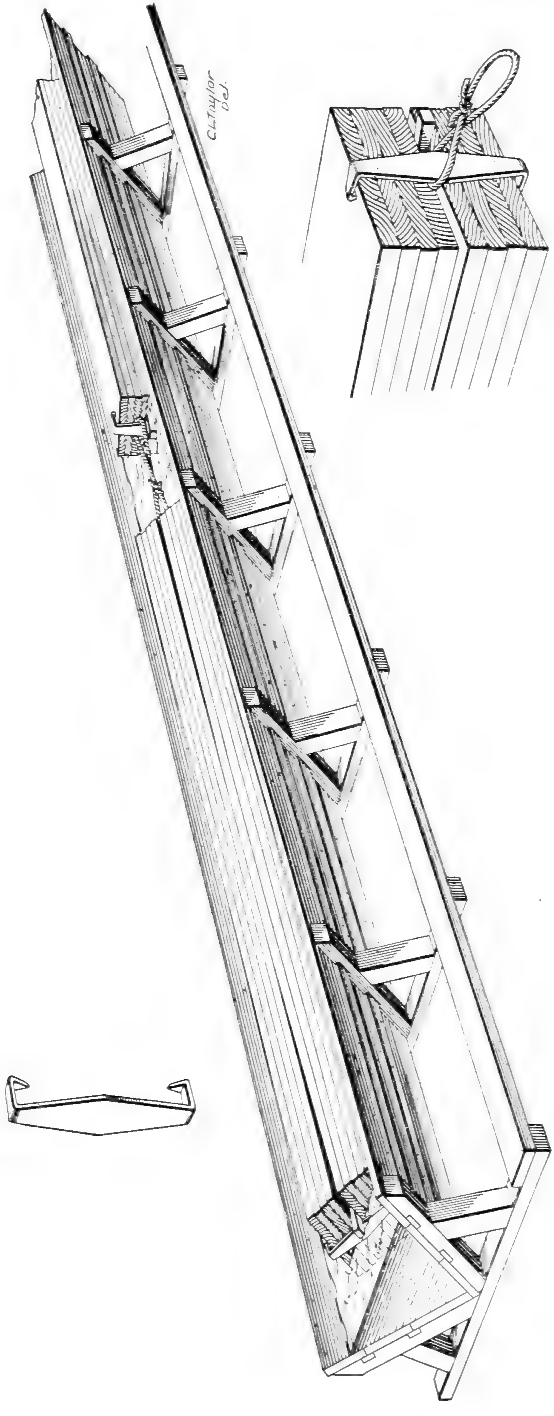


FIG. 7.—Method of clamping and accoutring brails of sawed lumber together for shipment.

upon this should depend largely the decision of what type or size of flume should be constructed. The capacity of a 24-inch V-shaped flume 10 miles in length, operated on a grade that was neither very flat nor exceptionally steep, with plenty of water, has been demonstrated as being capable of handling 25,000,000 feet b. m. of railroad crossties and lumber per annum, under especially favorable conditions.

For handling small material, such as railroad crossties, cordwood, mining stulls or props, and loose lumber, a 30-inch V-shaped flume (inside measurement) will usually be found of sufficient capacity for most any requirement, provided the grade is neither too flat nor too steep. Where either of these exceptions obtain, the size of the flume should preferably be increased to 36 to 40 inches.

For a log flume nothing less than a 36-inch V-shaped flume should be built, and a 40 to 60 inch V would be preferable, even for medium-sized logs, if there is a sufficient volume of water available. To operate a log flume successfully and economically there should be a sufficient volume of water available to fill the flume three-fourths full on all moderate grades. It will be apparent that if the grade of a large log flume were very steep, a very large body of water would be required. The larger, longer, and heavier the material to be handled, the larger the size of the V should be, the lesser degree of curvature is permissible, and the stronger must be the construction work.

Tables showing the approximate amount of water in cubic feet required to fill a V-shaped flume on steady grades of different per cents will be found in another portion of this bulletin.

COST OF TRANSPORTING DIFFERENT CLASSES OF MATERIAL.

The cost of transporting material by flumes varies greatly according to the conditions under which the flume is being operated, the class of material, time of year, number of men necessary to operate the flume, and all the other factors that go to make up or reduce the expense of operation. Railroad crossties have been flumed a distance of 20 miles at an actual cost for operation alone of one-half cent per tie, or 15 cents per thousand; sawed lumber in cants of from 2 to 6 inches in thickness at approximately the same rate.

If a flume line is properly constructed on a favorable and steady grade where it can be operated with a plentiful supply of water, the actual cost of transportation alone is very slight after the flume is constructed. But the important fact should not be lost sight of that a flume works only in one direction and that all supplies intended to be used in lumbering operations have to be hauled to the head of the flume by animal or other power.

COST OF CONSTRUCTION.

The cost of constructing flumes will also vary a great deal with the conditions existing in the locality, the cost of lumber, cost of nails, and price of labor. In localities where it is possible to get a boiler, engine, and mill to the upper end of a proposed flume line cheaply and without being compelled to go to the expense of constructing a costly road, where there is plenty of timber easily accessible to the mill, which can be cheaply manufactured into lumber for purposes of construction, with low-priced labor, a flume can be constructed much more economically than in a locality where all these conditions were just the contrary. Rough lumber suitable for the construction of a flume can ordinarily be cut and fitted for construction work at a price varying from $7.50 to $10 for manufacture alone, exclusive of stumpage value.

So much depends upon the locality in which a flume is to be constructed, the price of labor, and the facilities for getting the necessary construction material cheaply, that it is impracticable to attempt any very close estimate on the total cost of any flume until all of the surrounding conditions are thoroughly understood. But in general, under favorable conditions, with a basis of $2.25 per diem for common labor and from $3.50 to $4 per diem for carpenters, not including board, suitably prepared lumber should be built into a flume for about $7.50 per thousand. This would be about the minimum figure, and the cost would be liable to range upward from this price to $12 or higher, according to the conditions and prices of labor.

The cost of the construction of the Bear Canyon flume in Montana, a 26-inch V 10 miles long, was approximately $2,000 per mile. The lumber cost $8.50 per thousand to manufacture and fit it for construction purposes, and it required about 100,000 feet b. m. to the mile. The labor cost $800 per mile, and $350 per mile was expended for nails, iron for trusses, and for cost of surveying. This flume was constructed a number of years ago when the cost of material and labor was less than it is to-day.

A flume constructed from Dayton to Woodrock along the Tongue River, in the Bighorn National Forest, Wyo., is said to have cost approximately $3,500 per mile, in round figures, the cost of different sections varying from $2,500 to $7,500 per mile. This was a 30-inch V flume. There was considerable rock work on this line; Granite Canyon had to be passed through, where in some localities the flume was practically pinned to the sides of the canyon walls; there were several rock tunnels to be made through projecting points; and there were necessarily some very high trestles to be constructed. Another difficult feature of the construction of this flume was that of building the line across several miles of very soft, spongy ground with an almost flat grade to contend with. This flume was also constructed several years ago when the prices of labor and material were not, in general, so high as at the present time.

Probably one of the best examples of modern V-shaped log-flume construction is a flume recently constructed on Rochat Creek, near St. Joe, Idaho. This flume, which is unusually large and strongly constructed for the purpose of handling large, heavy logs, and long timbers, is said to have cost approximately $8,000 per mile for the 5 miles of its length. This figure includes the cost of construction of a wagon road and telephone line equipment.

DISTANCE BETWEEN BENTS.

There is a decided difference in the opinion of different operators as to the distance that the bents should be placed apart in flume construction, some contending for a 16-foot bent or length of stringers and box on all tangents, while others favor a 12-foot bent. Each has its merits. If a cheap flume for temporary use and medium capacity is desired, then one with 16-foot bents and boxes will usually answer the purpose; that is to say, if the life of the flume is only desired to be from 4 to 6 years. If large material is to be handled and the life of the flume is to be for a long period of time, then the construction work should be stronger and more lasting. If heavy material is to be handled, even the 30-inch V box flume might well be constructed with bents 12 feet apart, and in some cases even less if durability and strength are essential features.

The trouble with the bents 16 feet apart usually is that the stringers are more apt to sag or twist, thereby letting the box sag on one side or the other. This usually causes the water in the flume to slop over at the point of sagging, and the water softens and washes out the foundations under the bents, so that eventually the section of the flume where this occurs becomes uneven in grade and therefore leaky. The result is that the work of repair is much increased and breakdowns in the transportation operations are more frequent. It is usually advisable to place the brackets or arms not more than 4 feet apart on any size or style of flume. When placed farther apart than this it usually permits of too much spring to the box boards, and springing means leaks, which wash out the foundation of the bents and in many kinds of soil, especially on side hills, causes expensive slides or washouts.

The same general principle applies in connection with the lining of a box, and there is much difference of opinion on the value of the different types of construction. It is contended by some operators that the 1½-inch box lining, strengthened with 1 by 4 inch battens firmly nailed over the joints on the outside, is much more satisfactory than the doubled 1-inch boards. It is contended that the 1-inch doubled box is not as rigid as the 1½-inch lining reinforced by the battens, and that the doubled box permits of a constant spring when heavy timber is passing through the flume. This causes the boards gradually to work apart and fill in between the two courses with bark and sediment, eventually causing the box to leak badly.

Another contention is that in relining there is never a good solid foundation to nail to, and that the nails keep working loose and catching passing timber, causing jams. It is claimed that, by the use of the 1½-inch or 2-inch box lining reinforced by the battens nailed on from the outside, the element of "spring" is materially reduced.

ADVISABLE METHOD OF NAILING.

In the construction of either type of box or the nailing on of the battens, the nails should, whenever possible, be driven from the outside and clinched on the inside of the box with the point of the nail turned *down* the flume. By so doing the nails become tighter as the inside of the box wears, since the flumed material strikes the nails and drives or draws them in harder. When the inside of the box is so badly worn that it is necessary to replace the lining, the new lining furnishes a solid substance through which to nail. Each style of construction has its particular merits, and the prospective operator should decide for himself which is more applicable to his needs.

Tables showing approximate amount of material necessary to construct flumes of different sizes follow:

TABLE 1.—*Weight of water in a 16-foot section of flume when filled to various depths.*

Slant depth.	Weight of water in a section of flume 16 feet long.	Slant depth.	Weight of water in a section of flume 16 feet long.	Slant depth.	Weight of water in a section of flume 16 feet long.
Inches.	*Pounds.*	*Inches.*	*Pounds.*	*Inches.*	*Pounds.*
20	1,390	34	4,010	48	7,990
22	1,680	36	4,490	50	8,670
24	2,000	38	5,010	52	9,360
26	2,350	40	5,540	54	10,100
28	2,710	42	6,110	56	10,900
30	3,110	44	6,740	58	11,700
32	3,560	46	7,300	60	12,500

END DUMP OF A FLUME LINE.

In this case the line was extended as necessity required, using the shipped material as the foundation for the extension.

TABLE 2.—*Amount of water required to fill flumes to various depths at different grades.*

Slant depth (inches).	Grade—per cent.															
	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20
	Flow—Cubic feet per second.															
20	10	14	17	19	22	24	26	28	29	31	32	34	36	39	41	43
22	13	18	22	25	28	31	33	36	38	40	42	44	47	51	54	56
24	16	23	28	32	36	39	42	45	48	51	53	55	60	64	68	71
26	20	28	34	40	45	49	53	56	60	63	66	69	74	79	84	89
28	24	34	42	48	54	59	64	68	72	76	80	84	90	96	102	108
30	29	41	50	58	65	71	77	82	87	92	96	101	109	116	123	130
32	35	49	60	69	78	85	92	98	104	109	115	120	130	138	147	155
34	41	58	71	81	91	100	108	115	122	129	136	142	153	163	173	183
36	48	67	82	95	107	117	126	135	143	150	158	165	178	190	202	212
38	55	78	95	110	123	135	145	156	165	174	182	190	206	220	233	245
40	63	89	109	125	140	154	166	178	189	199	209	218	235	251	266	281
42	72	101	127	143	160	175	189	203	215	226	237	248	267	286	304	319
44	81	114	140	163	181	199	214	229	243	257	269	281	303	325	344	362
46	91	130	158	183	204	223	241	258	274	289	302	316	341	365	387	408
48	102	144	177	205	230	251	271	290	307	323	340	354	383	410	434	458
50	115	161	198	228	255	279	302	323	343	360	378	397	428	456	483	510
52	127	179	219	253	283	311	336	358	381	401	420	440	475	507	537	567
54	140	198	242	281	313	342	371	396	421	443	465	484	524	560	594	626
56	156	220	269	311	348	383	412	440	467	492	517	538	583	621	661	697
58	170	241	295	339	380	415	449	481	510	537	564	589	636	681	721	759
60	186	262	322	372	415	455	492	525	558	589	616	644	695	744	788	831

TABLE 3.—*Velocity of water in flumes when filled to various depths at different grades.*

Slant depth (inches).	Grade—per cent.															
	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20
	Velocity of water—Miles per hour.															
20	5	7	8	9	11	12	13	13	14	15	16	17	18	19	20	21
22	5	7	9	10	11	13	14	14	15	16	17	18	19	21	22	23
24	5	8	9	11	12	13	14	15	16	17	18	19	20	22	23	24
26	5	8	10	12	13	14	15	16	17	18	19	20	22	23	24	26
28	6	9	10	12	14	15	16	17	18	19	20	21	23	24	26	27
30	6	9	11	13	14	16	17	18	19	20	21	22	24	25	27	29
32	7	9	11	13	15	16	18	19	20	21	22	23	25	27	28	30
34	7	10	12	14	15	17	18	20	21	22	23	24	26	28	29	31
36	7	10	12	14	16	18	19	20	22	23	24	25	27	29	31	32
38	7	11	13	15	17	18	20	21	22	24	25	26	28	30	32	33
40	8	11	13	15	17	19	20	22	23	24	26	27	29	31	33	35
42	8	11	14	16	18	20	21	23	24	25	26	28	30	32	34	36
44	8	12	14	16	18	20	22	23	25	26	27	29	31	33	35	37
46	8	12	15	17	19	21	22	24	25	27	28	29	32	34	36	38
48	9	12	15	17	20	21	23	25	26	28	29	30	33	35	37	39
50	9	13	16	18	20	22	24	25	27	28	30	31	34	36	38	40
52	9	13	16	18	21	23	24	26	28	29	31	32	35	37	39	41
54	9	13	16	19	21	23	25	27	28	30	31	33	35	38	40	42
56	10	14	17	19	22	24	26	28	29	31	32	34	36	39	41	43
58	10	14	17	20	22	24	26	28	30	31	33	34	37	40	42	44
60	10	14	18	20	23	25	27	29	30	32	34	35	38	41	43	45

In the preparation of these tables the formula $v=c\sqrt{r\,s}$ was used, in which v = the velocity of the water in feet per second, c = a constant, r = the hydraulic radius in feet, and s = the slope. Each step was carried out to three significant figures. The following values for c and r were used:

Slant depth.	c	r	Slant depth.	c	r	Slant depth.	c	r
Inches.			*Inches.*			*Inches.*		
20	108	0.417	34	121	0.708	48	128	1.00
22	111	.458	36	122	.750	50	129	1.04
24	113	.500	38	123	.792	52	130	1.08
26	115	.542	40	124	.833	54	131	1.12
28	116	.583	42	125	.875	56	132	1.17
30	118	.625	44	126	.917	58	132	1.21
32	119	.667	46	127	.958	60	133	1.25

This formula is based upon experiments with slopes of less than 10 per cent, and while its application to steeper grades has not been thoroughly checked by actual determinations of velocity, the results are considered sufficiently accurate for use in the design of timber flumes.

TABLE 4.—*Estimate of approximate amount of material required for construction of flumes.*

26-INCH "V" FLUME WITH 1½-INCH BATTENED BOX.

Kinds of lumber.	Lumber required per mile.								Nails required per mile.		
	Dimensions.		Feet to piece.	Pieces to each box.	Feet to each box.	Pieces per mile.	Boxes per mile.	Feet b. m. per mile.	Size.	Pounds.	Kegs.
	Size.	Length.									
	Inches.	*Ft. in.*	*Ft. in.*		*Ft. in.*						
Mud sills	4 x 4	7 3	9 8	1	9 8	330	330	3,190	10-penny	763	7¾
Posts	4 x 4	7 3	9 8	2	19 4	660	330	6,380	12-penny	682	6¾
Caps	4 x 4	3 6	4 8	1	4 8	330	330	1,540	16-penny	113	1
Braces, sway	1 x 6	9 0	4 6	2	9 0	660	330	2,970	20-penny	425	4¼
Braces, lateral	1 x 6	7 6	3 9	4	15 0	[1] 1,100	[1] 275	[1] 4,125			
Stringers	4 x 6	16 0	32 0	2	64 0	660	330	21,120	One keg of 40-penny nails and 1 keg of 60-penny nails should usually be allowed for such preliminary work as bridging, etc.		
Sills	2½ x 4	4 6	3 9	3	11 3	990	330	3,713			
Braces	2½ x 4	0 11	0 10	6	5 0	1,980	330	1,650			
Arms	2½ x 4	2 2	1 9⅔	6	10 10	1,980	330	3,575			
Box boards	1½ x 54	16 0	([2])	......	108 0	......	330	35,640			
Battens	1 x 4	5 0	1 8	12	20 0	3,960	330	6,600			
Running boards	1½ x 10	16 0	20 0	1	20 0	330	330	6,600			
								97,103			
Add for waste								2,897			
Total								100,000	Total	1,983	19¾

[1] Lateral braces are only figured for five-sixths of a mile, as at least one-sixth of each mile, on an average, will be too close to the ground to require the use of these braces.
[2] Various sizes.

TABLE 4.—*Estimate of approximate amount of material required for construction of flumes*—Continued.

30-INCH "V" FLUME WITH 1-INCH DOUBLE BOX.

Kinds of lumber.	Lumber required per mile.								Nails required per mile.		
	Dimensions.		Feet to piece.	Pieces to each box.	Feet to each box.	Pieces per mile.	Boxes per mile.	Feet b. m. per mile.	Size.	Pounds.	Kegs.
	Size.	Length.									
	Inches.	*Ft. in.*	*Ft. in.*		*Ft. in.*						
Mud sills	4 x 6	7 8	15 4	1	15 4	330	330	5,060	10-penny	500	5
Posts	4 x 6	7 3	14 6	2	29 0	660	330	9,570	12-penny	528	5¼
Caps	4 x 6	4 7	9 2	1	9 2	330	330	3,025	16-penny	948	9½
Braces, sway	1 x 6	9 2	4 7	2	9 2	660	330	3,025	20-penny	156	1½
Braces, lateral	1 x 6	7 6	3 9	4	15 0	[1] 1,100	[1] 275	[1] 4,125			
Stringers	4 x 8	16 0	42 8	2	85 4	660	330	28,160	One keg of 40-penny nails and one keg of 60-penny nails should usually be allowed for such preliminary work as bridging, etc.		
Sills	2½ x 5	5 4	5 6⅔	3	16 8	990	330	5,500			
Braces	2½ x 5	1 1	1 1½	6	6 9	1,980	330	2,228			
Arms	2½ x 5	2 6	2 7¼	6	15 7½	1,980	330	5,157			
Box boards	2 x 62	16 0	(2)	......	165 4	......	330	54,560			
Running boards	1½ x 10	16 0	20 0	1	20 0	330	330	6,600			
								127,010			
Add for waste	......	......	......	......	......	......	......	7,990			
Total	......	......	......	......	......	......	......	135,000	Total	2,132	21¼

30-INCH "V" FLUME WITH 1½-INCH BATTENED BOX.

Kinds of lumber.	Size.	Length.	Feet to piece.	Pieces to each box.	Feet to each box.	Pieces per mile.	Boxes per mile.	Feet b. m. per mile.	Size.	Pounds.	Kegs.
Mud sills	4 x 6	7 8	15 4	1	15 4	330	330	5,060	10-penny	763	7¾
Posts	4 x 6	7 3	14 6	2	29 0	660	330	9,570	12-penny	780	7¾
Caps	4 x 6	4 7	9 2	1	9 2	330	330	3,025	16-penny	113	1
Braces, sway	1 x 6	9 2	4 7	2	9 2	660	330	3,025	20-penny	425	4¼
Braces, lateral	1 x 6	7 6	3 9	4	15 0	[1] 1,100	[1] 275	[1] 4,125			
Stringers	4 x 8	16 0	42 8	2	85 4	660	330	28,160	One keg of 40-penny nails and 1 keg of 60-penny nails should usually be allowed for such preliminary work as bridging, etc.		
Sills	2½ x 5	5 4	5 6⅔	3	16 8	990	330	5,500			
Braces	2½ x 5	1 1	1 1½	6	6 9	1,980	330	2,228			
Arms	2½ x 5	2 6	2 7¼	6	15 7½	1,980	330	5,157			
Box boards	1½ x 62	16 0	(2)	......	124 0	......	330	40,920			
Battens	1 x 4	5 0	1 8	12	20 0	3,960	330	6,600			
Running boards	1½ x 10	16 0	20 0	1	20 0	330	330	6,600			
								119,970			
Add for waste	......	......	......	......	......	......	......	5,030			
Total	......	......	......	......	......	......	......	125,000	Total	2,091	20¾

36-INCH "V" FLUME WITH 1½-INCH BATTENED BOX.

Kinds of lumber.	Size.	Length.	Feet to piece.	Pieces to each box.	Feet to each box.	Pieces per mile.	Boxes per mile.	Feet b. m. per mile.	Size.	Pounds.	Kegs.
Mud sills	4 x 6	8 6	17 0	1	17 0	440	440	7,480	10-penny	1,300	13
Posts	4 x 6	7 3	14 6	2	29 0	880	440	12,760	12-penny	396	4
Caps	4 x 6	5 0	10 0	1	10 0	440	440	4,400	16-penny	1,075	10¾
Braces, sway	1 x 6	10 0	5 0	2	10 0	880	440	4,400	20-penny	447	4½
Braces, lateral	1 x 6	7 6	3 9	4	15 0	[1] 1,467	[1] 366⅔	[1] 5,500			
Stringers	4 x 8	12 0	32 0	2	64 0	880	440	28,160	One keg of 40-penny nails and one keg of 60-penny nails should usually be allowed for such preliminary work as bridging, etc.		
Sills	3 x 5	6 0	7 6	3	22 6	1,320	440	9,900			
Braces	3 x 5	1 5	1 9¼	6	10 7½	2,640	440	4,675			
Arms	3 x 5	3 0	3 9	6	22 6	2,640	440	9,900			
Box boards	1½ x 74	12 0	(2)	......	111 0	......	440	48,840			
Battens	1 x 4	4 0	1 4	18	24 0	7,920	440	10,560			
Running boards	1½ x 10	12 0	15 0	1	15 0	440	440	6,600			
								153,175			
Add for waste	......	......	......	......	......	......	......	6,825			
Total	......	......	......	......	......	......	......	160,000	Total	3,218	32¼

[1] Lateral braces are only figured for five-sixths of a mile, as at least one-sixth of each mile, on an average, will be too close to the ground to require the use of these braces.
[2] Various sizes.

TABLE 4.—*Estimate of approximate amount of material required for construction of flumes*—Continued.

54-INCH "V" FLUME WITH 2-INCH BATTENED BOX.

Kinds of lumber.	Lumber required per mile.								Nails required per mile.		
	Dimensions.		Feet to piece.	Pieces to each box.	Feet to each box.	Pieces per mile.	Boxes per mile.	Feet b. m. per mile.	Size.	Pounds.	Kegs.
	Size.	Length.									
	Inches.	*Ft. in.*	*Ft. in.*		*Ft. in.*						
Mud sills	6 x 6	10 0	30 0	1	30 0	440	440	13,200	12-penny	1,700	17
Posts	6 x 6	7 3	21 9	2	43 6	880	440	19,140	16-penny	1,075	10¾
Caps	6 x 6	7 0	21 0	1	21 0	440	440	9,240	20-penny	390	4
Braces, sway	1½x 6	11 0	8 3	2	16 6	880	440	7,260	40-penny	3,625	36¼
Braces, lateral	1½x 6	7 6	5 7½	4	22 6	[1] 1,467	[1] 366⅔	8,250			
Stringers	6 x 8	12 0	48 0	2	96 0	880	440	42,240	One keg of 40-penny nails and one keg of 60-penny nails should usually be allowed for such preliminary work as bridging, etc.		
Sills	4 x 6	7 0	14 0	3	42 0	1,320	440	18,480			
Braces	4 x 6	1 9½	3 7	6	21 6	2,640	440	9,460			
Arms	4 x 6	4 6	9 0	6	54 0	2,640	440	23,760			
Box boards	2 x110	12 0	([2])	....	220 0	....	440	96,800			
Battens	1¼x 4	4 0	1 8	24	40 0	10,560	440	17,600			
Running boards	2 x 12	12 0	24 0	1	24 0	440	440	10,560			
								275,990			
Add for waste	....	....	....	....	....	....	....	9,010			
Total	....	....	....	....	....	....	....	285,000	Total	6,790	68

[1] Lateral braces are only figured for five-sixths of a mile, as at least one-sixth of each mile, on an average, will be too close to the ground to require the use of these braces.
[2] Various sizes.

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