SOLID LOG WALL CONSTRUCTION

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Introduction/Preamble

This booklet about solutions to problems encountered with building solid log walls is intended to assist log home buyers and builders, building officials, home owners and lending institutions. Problems are described, their causes defined and solutions to the problems are outlined. Problems range from those that can be hazardous, or may lead to deterioration of the building structure, through some which are merely unsightly.

Most problems with log construction can be avoided through careful design, selection of logs and construction practice and by appropriate handling of log building materials. Some periodic maintenance requirements are described.

There are many log profiles used in building log walls - from natural logs each custom-scribed to fit the log below - to square, rectangular or partly round shapes with various tongue and groove patterns or provision for splines. Both hand-crafted and manufactured log house construction can give acceptable results when workmanship is good. A high degree of air-tightness can be achieved with either system when proper care is taken. Hand-crafted log buildings are usually fitted at one site then dismantled for shipping and reassembled at the building site. Manufactured logs are usually partly dried so that somewhat less settlement may be expected; and sometimes they are dipped in preservative and/or water repellant after milling. In some locations hand-crafted logs from dead standing timber may be partly dried before construction, but generally logs for hand-crafted log houses are green when scribed and shaped.

It is considered prudent to allow 3/4 inch per foot of log wall height for the settlement which occurs due to shrinkage plus closing up of the gaps between the logs in a wall when the wall is made with green or partly dry logs. When partly dry manufactured logs are used the settlement allowance is reduced. What is certain is that every wall constructed with horizontal logs will settle! The settlement **must** be expected and allowed for.

Moisture

Wood is a hygroscopic material which means that it will take on and give off moisture depending on the relative humidity and air temperature and on the moisture content (MC) of the wood. As logs dry they shrink and the shrinkage contributes to settlement. During humid summer conditions wood will absorb moisture from the air. During winter when relative humidity of outside air is low, logs will dry. There is a continuing change in the MC and consequently in the dimensions of every piece of wood used in log construction. Joints between logs must be capable of moving to accomodate the changes in dimension without distress. Materials used to seal gaps at joints must be flexible or they will crack and the seal will be ineffective.

Because wood is subject to attack by insects, stain and decay fungi, it is essential to its long-term performance that wood be protected from conditions which permit insects and fungi to flourish. The best method is to **keep it dry!** The long life of covered bridges and old wood buildings with large roof overhangs and steep roofs attest to the effectiveness of keeping wood dry.

Moisture is the cause of many problems of major importance with log construction as is it with building materials in general. Most important is to protect wood from excessive moisture! When the moisture content (MC) of wood is kept below about 20 percent, stain and decay fungi cannot grow. Wood MC is expressed as weight of water divided by the oven-dry weight of wood substance. The MC of wood in living trees ranges from about 23 percent for heartwood of some species to nearly 200 percent for sapwood of other species.

Large roof overhangs help keep rain off and thus help to prevent log walls from absorbing water. Keeping shrubs and landscaping plants away from and avoiding sprinkling near log walls help to minimize moisture build-up and contribute to good performance of log walls. The bottom log in a wall should be at least one foot above grade (preferably more) to help keep its MC low.

Energy consumption

The energy consumption of residential construction has a great effect on Canada's economy and thus on the well-being of all Canadians. Many factors affect the

energy consumption of residential construction including thermal resistance of the building materials used, air-tightness of the construction, temperatures maintained, ventilation, occupant habits and the mass of the materials used. Thermal resistance of log walls has been a subject of discussion for some years. The question of how to assess relative energy consumption for log houses is now under review, but the 'R' factor is still considered important.

There is a vocal school of thought among log house proponents to the effect that other factors affect energy efficiency of log buildings. A 'mass' effect in which the logs absorb energy and slowly release it as temperatures change is said to make log buildings comfortable with less energy consumption than 'R' alone would indicate, for both heating and cooling. Another way to think of this is as thermal lag or thermal inertia. The thermal mass effect is now reflected in the CMHC-accepted 'R' values. More work may soon cast light on the best ways to recognize the important factors in energy use in log buildings.

Some 'trade-offs' among the insulation requirements for various components of log houses may be permitted by building officials to achieve acceptable energy efficiency.

The values now accepted by CMHC for thermal resistance 'R' of log walls, those found in recent field test work by Scanada Consultants Limited plus recommended values from a recent extensive literature review for the U.S. Department of Energy are shown in Table 1, below.

Table 1. Thermal Resistance ($h\text{-}ft^2\text{-}°F/Btu\text{-}in$)

Species	CMHC-accepted*	Scanada**	TenWolde et al***
Pine (white)	1.38	0.98	1.3
Cedar (white)	1.46	1.2	1.5

* Including 10% allowance for thermal mass storage.

** SCANADA CONSULTANTS LIMITED. 1986. Log walls field tests. Report prepared for Canada Mortgage and Housing Corporation. 54pp.

*** TenWolde, A., J. D. McNatt and L. Krahn. 1988. Thermal properties of wood and wood panel products for use in buildings. Report prepared by USDA Forest Products Laboratory for ... U.S. Department of Energy (DOE/USDA-21697/1) 43pp.

The thermal resistance 'R' of a typical white pine hand-crafted full-scribed log wall with logs having mean top and butt diameters of 10 and 17 in. respectively would be taken as mean thickness times 1.38 (ie. about 0.9 x 13.5 x 1.38 = 16.7 (imperial measure).

Species Characteristics

Most species of commercial woods have been used for Canadian log building. Some species are preferred for their good attributes while others require more care in construction and in service to ensure good performance. Some features of interest for log building are listed below.

Softwoods - generally higher 'R' factor, generally easy to work

Hardwoods - generally more difficult to work but strong - good for floor & roof framing because of strength. More headroom possible because smaller log floor joists can be used (oak, ash, cherry, ironwood)

Balsam fir - good 'R', straight, weak, easily worked, small diameter logs

Cedar (Western Red, and Eastern White) - excellent 'R', straight, decay resistant, not round, easy to work, light weight, low shrinkage

Douglas-fir - low 'R', strong heavy and hard, straight, straight-grain, harder to work

Hemlock - low 'R', prone to shake in the living tree, hard to work with, strong

Larch - straight, strong, heavy and hard, low 'R', hard to work

Poplars - good 'R', not straight, prone to warp, shake and spiral grain; decays easily

Red pine - straight, develops stain and decay quickly (especially with bark on), fairly easy to work, good 'R', lower strength

Spruce - Straight, good 'R', prone to spiral grain, many knots, high shrinkage, relatively easy to work, strong

White pine - may not be straight, good 'R', slow drying with little shrinkage, very little spiral grain, easily worked, large logs available

Handling logs.

Logs should be peeled as soon after felling as possible but may be hard to peel when partly dry or frozen. When peeling logs do not cut into the smooth shiny layer just inside the bark. Logs should be carefully handled at the construction site to avoid marks from mud and boots which can be difficult to remove.

It is considered ideal to use winter-cut logs in hand-crafted log construction. Good results are obtained when logs are peeled before mid-May, and placed and covered over with a roof as soon as possible - before warm moist weather. This prevents or minimizes discolouration by stain or mould fungi. Considerable drying of the logs will occur if the building shell is then allowed to remain open under its roof for several months.

Moisture Problems

1. **PROBLEM: Stain** on logs.

   CAUSE: Attack by mould and stain fungi.

   SOLUTION: Peel shortly after felling, stack above ground, allow logs to dry. Mould grows quickly in moist weather. Household bleach may be scrubbed on immediately after mould or stain is noticeable.

   CAUSE: Attack by mould and stain fungi.

   SOLUTION: Bleach the stain to lighten the colour then protect the logs to prevent the build up of **high moisture content,** which the fungi need to live.

   CAUSE: Rough spots on log surfaces (especially near knots) readily absorb **moisture** (needed for stain or mould fungi to live).

   SOLUTION: Smooth the cut surfaces at knots, protrusions and window sills with a plane or surface planer, and when logs have dried, apply water-repellant surface finish.
   Illustration Photo No. 2.

2. **PROBLEM: Wet** wood leads to stain and decay of lowest logs in log walls at foundation.

   CAUSE: High **moisture content** due either to capillary action or to water not being shed quickly enough from log walls in driving rain, especially near the bottom of the wall.

   SOLUTION: Use drip starter for sill logs - saw kerf or metal - to prevent capillary action.
   Illustrations Sketches No. 1, No. 2.

3. **PROBLEM: Discolouration** of finished logs after a few years in service.

   CAUSE: Deterioration and discolouration from exposure to ultra violet radiation.

   SOLUTION: Use wood finishes with u-v 'blocking' pigment. Suitable wood finishes for exterior use on logs are non-film-forming finishes such as penetrating stain with pigment. The pigmented stains are almost as effective as paint for blocking u-v which causes degradation of the surface of exposed wood. Some wood finishes for exterior use contain wood preservatives.

   Note: Wood preservatives must be handled with great care because they are toxic to living organisms, so care in use is very important for the health of all.

4. **PROBLEM: Moisture build-up** in log walls.

   CAUSE: Many possible water sources must be considered including shrubs or bushes near a wall, inadequate roof overhang.

   SOLUTION: Use details which facilitate the shedding of rain water by wall surfaces and details to keep rain off log walls such as large roof overhangs and roofs over gable end log walls (with soffit at same level as soffit of side walls.)
   Illustrations Sketches No. 3, 4, 5 and 6.

   SOLUTION: Use water repellant finish to reduce absorbancy of log surface.

5. **PROBLEM:** Severe twist of second floor joists.

   CAUSE: Rapid drying at ceiling level of joists containing spiral grain .

   SOLUTION: Restrain log joists by framing joists into log wall using mortice and tenon joints or avoid using logs with spiral grain for joists.
   Illustration Sketch No 7.

6. **PROBLEM:** Gaps in walls where logs get 'hung up' at window or door openings.

CAUSE: Inadequate allowance for **settlement** due to the combination of shrinkage of the logs as they dry plus the closing up of the gaps between logs.

SOLUTION: Provide for settlement of 3/4 in. per foot of wall height. If logs are partly dried at time of construction this allowance may be reduced accordingly, but it must be recognized that settlement is due not only to shrinkage of the logs.
Illustration Photo No. 3.

7. **PROBLEM:** Unsightly finish when settlement occurs at junction between log exterior wall and interior frame partition wall.

CAUSE: Log wall **settlement**.

SOLUTION: Use detail that permits vertical movement of the log wall yet does not expose unfinished wall or trim when settlement occurs.
Illustration Sketch No.8.

8. **PROBLEM:** Unsightly joints between interior frame walls and ceilings.

CAUSE: **Settlement** of log construction occurs, but frame construction does not settle so joint must permit the ceiling to move down without showing that movement has occurred.

SOLUTION: Provide a gap over frame walls to allow the settlement to occur while providing lateral restraint at top of frame walls. Use trim detail to conceal gap.
Illustration Sketch No 9.

9. **PROBLEM:** Bending of electrical entry mast.

CAUSE: **Settlement** of log construction not provided for.

SOLUTION: Leave upper clamps just snug to permit the mast to slide with respect to the logs when settlement occurs, and only fasten tightly the lowest clamp on the mast.
Illustration Sketch No.10.

10. PROBLEM: Water leaks around fireplace chimney.

CAUSE: Settlement of log construction greater than flashing could accomodate.

SOLUTION: Allow for 3/4 in. of settlement per foot of log wall height and use counter flashing.

11. PROBLEM: Water leaks at junction of log wall and roof over wood frame construction.

CAUSE: Differential **settlement** creates flashing problems - log and wood frame construction do not settle equally.

SOLUTION: Use counterflashing to provide for movement (settlement) of log wall.
Illustration Sketch No. 11 (of counter flashing).

12. PROBLEM: Water leaks at window and door openings.

CAUSE: Poor details - must both seal and permit **settlement.**

SOLUTION: Use flashing over window, cut logs near maximum diameter both above and below windows, provide for window sills to shed rain water.
Illustrations Sketches No. 12, 13.

13. PROBLEM: Plumbing leaks.

CAUSE: Settlement puts stress on joints in water supply and drain pipes.

SOLUTION: Allow enough flexibility to accomodate settlement in plumbing runs so that, after settlement, there is enough slope in 'horizontal' run of pipes before they lead to upper level to permit drain pipes and water supply pipes to drain.
Illustration Sketch No. 14.

SOLUTION: Use 'swing' joint connections utilizing threaded elbows in plumbing pipes to provide enough flexibility.
Illustrations Sketch No. 15.

SOLUTION: Use loop of 'soft' copper water supply pipe in vertical run between floors to accommodate settlement without overstressing pipes or joints.
Illustration Sketch No. 16.

SOLUTION: Use slip joint in vertical run of drain pipe between floors to accommodate settlement without overstressing pipes or joints.
Illustration Sketch No. 16.

14. PROBLEM: Electrical faults.

CAUSE: Settlement puts stress on connections at junction boxes or switches and can cause short circuits.

SOLUTION: Plan for wiring and do it as construction proceeds making allowance for movement of wiring when settlement occurs, by providing room in holes or chases drilled vertically in log walls - ie. 1.5 or 2 in. diameter.
Sketch No. 17.

SOLUTION: Place wiring behind spline at rough opening for door.
Illustration Sketch No. 17.

SOLUTION: Avoid using conduit because it may cut the insulation on wiring when the inevitable settlement occurs.

Air Leakage Problems

15. PROBLEM: Air leakage through joints in log walls.

CAUSE: Ineffective sealing techniques.

SOLUTION: Minimize air movement through joints by using proven methods for sealing joints:

a) Scribed joints, properly formed in hand-crafted construction, with cavities sealed with closed cell foam or glass fibre. (The use of glass fibre insulation in cavities in scribed log construction is widespread, but concern has been voiced by some log builders that, if it is not properly trimmed after settlement, it may act as a 'wick' and permit moisture to build up and over a long time to permit the growth of decay.)

b) Double tongue and groove joints in manufactured logs, with closed cell foam seal/filler, sometimes called foam tape.

c) Splines of plywood used to block air movement

d) Chinking, carefully done with proper materials - eg. closed cell foam plus a coating of a flexible sealant applied in a coat thin enough to flex.

Illustrations Sketches No. 3, 4, 5, and 18. Photo No. 4.

CAUSE: Ineffective sealing technique permits air leakage at joint between foundation and base logs.

SOLUTION: Use a compressible material between foundation and sill logs - such as expanded polystyrene foam or closed cell foam.

Illustration Sketch No 19.

CAUSE: Ineffective sealing permits air leakage around windows and doors.

SOLUTION: Use closed cell foam for packing between windows and doors and the rough openings left for them.

Distortion Problems

16. **PROBLEM:** Distortion of log wall near door with cantilevered porch roof.

CAUSE: Load from roof causes bending of wall.

SOLUTION: Use stiff spline in door opening, also arrange support for roof to reduce wall bending.

Illustration Sketch No. 20.

17. **PROBLEM:** Log walls move outward at top.

CAUSE: No restraint against thrust from roof rafters.

SOLUTION: Provide restraint against outward movement with floor joists tied into top of wall using locking joint such as dovetail or square notch between joists and walls, or collar ties, or design the top of the wall to act as a horizontal beam capable of resisting the thrust.

Illustrations Sketches No. 21 and 29.

18. PROBLEM: Long walls do not stay straight.

CAUSE: Long walls may need lateral stiffening.

SOLUTION: Provide bracing with a partition wall at right angles to a long wall or pegs at mid-length for unsupported solid log walls over approximately 24 feet long.

19. PROBLEM: Doors or windows don't move freely.

CAUSE: Log wall movement - out of plumb.

SOLUTION: Use spline at rough opening. Splines should be stiff - hardwood or steel T bar or square steel tube. Fasten window to spline - NOT to logs. Fasten trim to window - NOT to logs.
Illustrations Sketch 22.

20. PROBLEM: Distortion of log walls at end-to-end joints in logs. Logs 'hanging up' when settlement occurs.

CAUSE: Restraint for logs against lateral movement.

SOLUTION: When spikes, lag bolts or through-bolts are used to restrain and to 'pull' logs down into line it is important to countersink the heads of lag bolts, through-bolts or spikes to permit settlement to take place freely.
Illustration Sketch No. 23.

21. PROBLEM: Interior log walls develop gaps between logs.

CAUSE: Rapid drying of interior logs.

SOLUTION: Humidify indoors for first 3 heating seasons or use frame construction for interior walls.

Miscellaneous

22. PROBLEM: Safety hazards of handling heavy logs at construction site.

CAUSE: Clutter, poor access.

SOLUTION: Use ramps with cleats and scaffolding.

23. PROBLEM: Gaps or openings due to **twist** of logs in service.

CAUSE: Spiral grain.

SOLUTION: Restrain spiral grain logs while drying using dowels or reduce twist by kerfing, with saddle notches or other structural restraint (Tenons).
Illustrations Sketch No. 25. Photo No. 5.

24. PROBLEM: Poor fit between scribed logs.

CAUSE: Can be due to upper log splitting.

SOLUTION: Keep the size of the cut-out for the cavity of the upper log as small and as 'smooth' as possible, avoiding V shaped cavity to prevent stress concentration which may lead to splitting.
Illustration Sketch No 25. Photo No. 6.

25. PROBLEM: Splitting of log ends beyond corners.

CAUSE: Not enough projection past corner.

SOLUTION: Provide minimum projection of about 1.5 times the log butt diameter past the centre of the intersection of the logs at the corner.
Illustration Sketch No. 26.

26. PROBLEM: Splitting of ends of log joists.

CAUSE: Notch at tenon creates stress concentration.

SOLUTION: Avoid using sharp corners at notches and keep notches small. A suggested rule of thumb is to limit the notch depth to 15% of the joist depth and to provide a gradual transition from notch back to full depth at each end of joist.
Illustration Sketch No. 27.

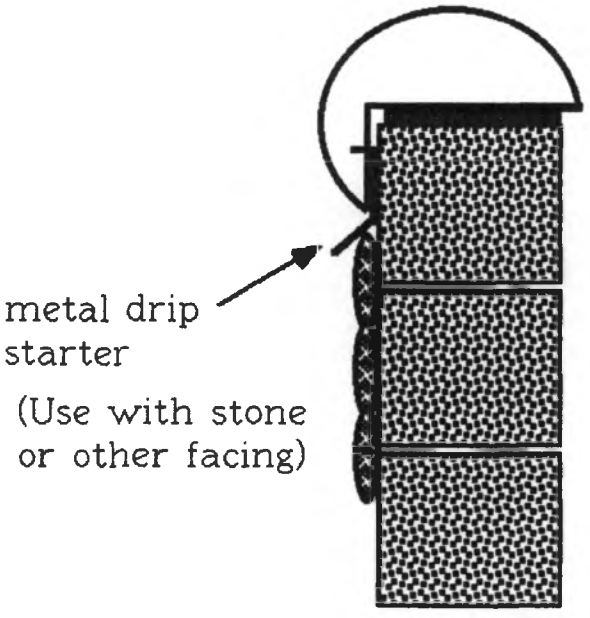
27. PROBLEM: Uneven second floor after settlement, when timber framing used to support second floor; also uneven roof line for attached porch.

CAUSE: Inadequate provision for settlement at columns.

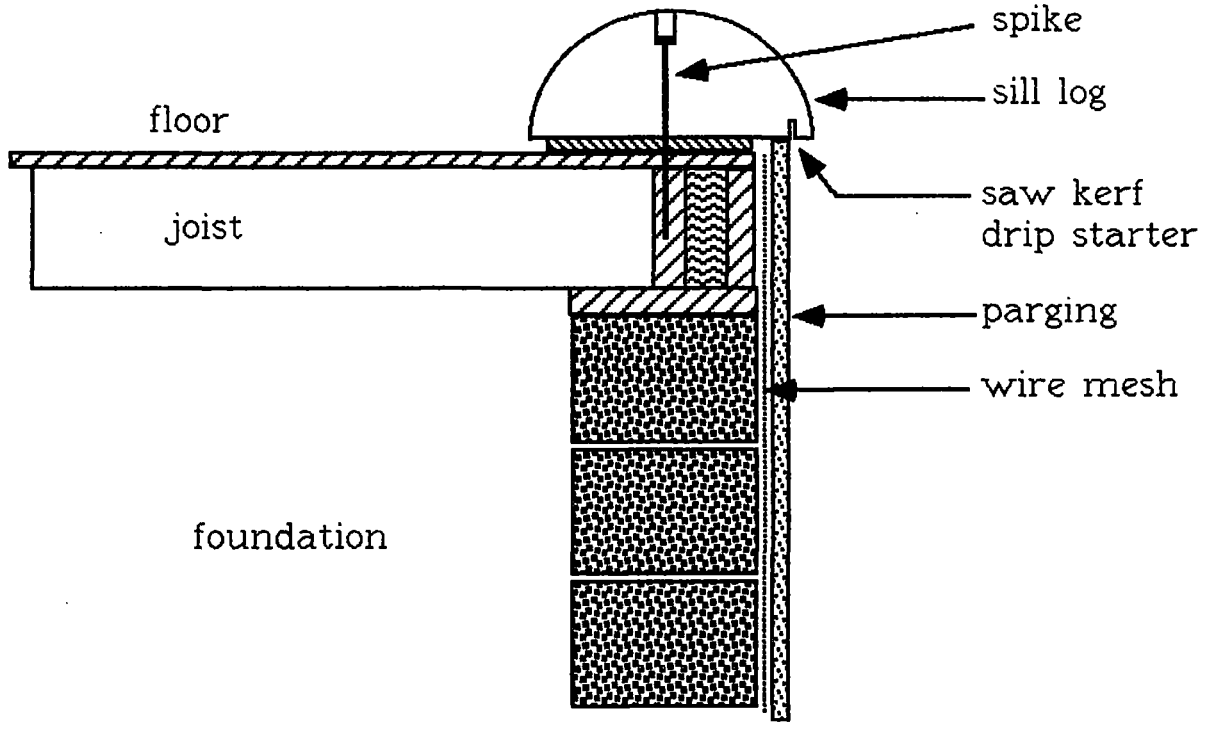
SOLUTION: Provide for adjustment of column-base height to compensate for log settlement and to permit levelling floor, or to maintain desired roof line for porch.
Illustration Sketch No. 28.

Note to CMHC It is proposed to use Photos 2 to 6 as shown in the original draft.

Sketches prepared by computer are attached.



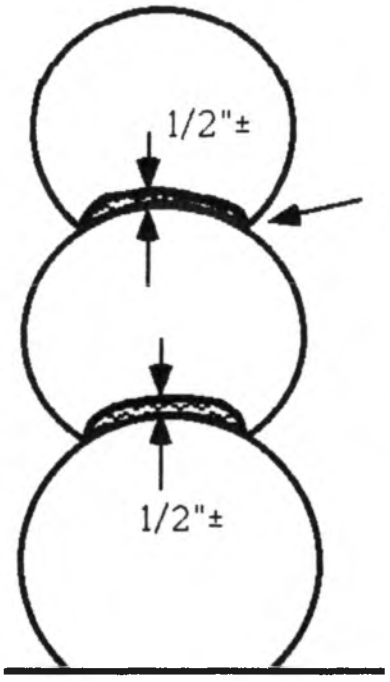
Sketch No. 1


spike
sill log
floor
joist
saw kerf
drip starter
parging
wire mesh
foundation

Sketch No. 2

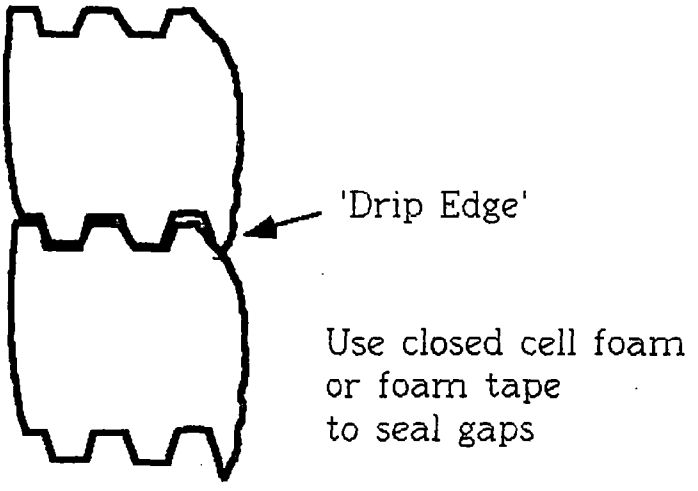
Insulate cavity with closed-cell foam (or glass fibre)

When using glass fibre insulation, ensure that it protrudes beyond drip edge when setting logs, but it **must** be cut off with a sharp knife to prevent wick action



drip edge (hand-crafted scribed logs)

Sketch No. 3



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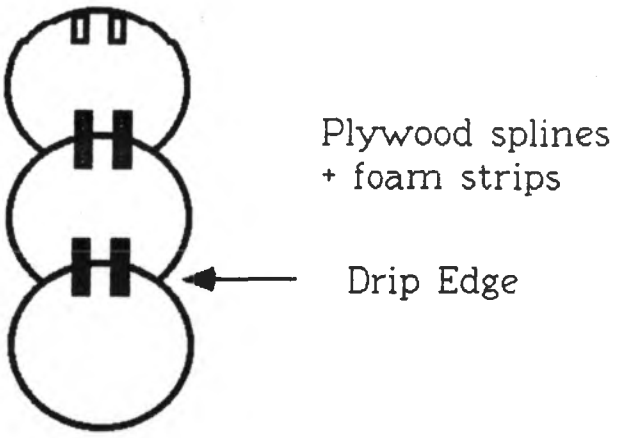

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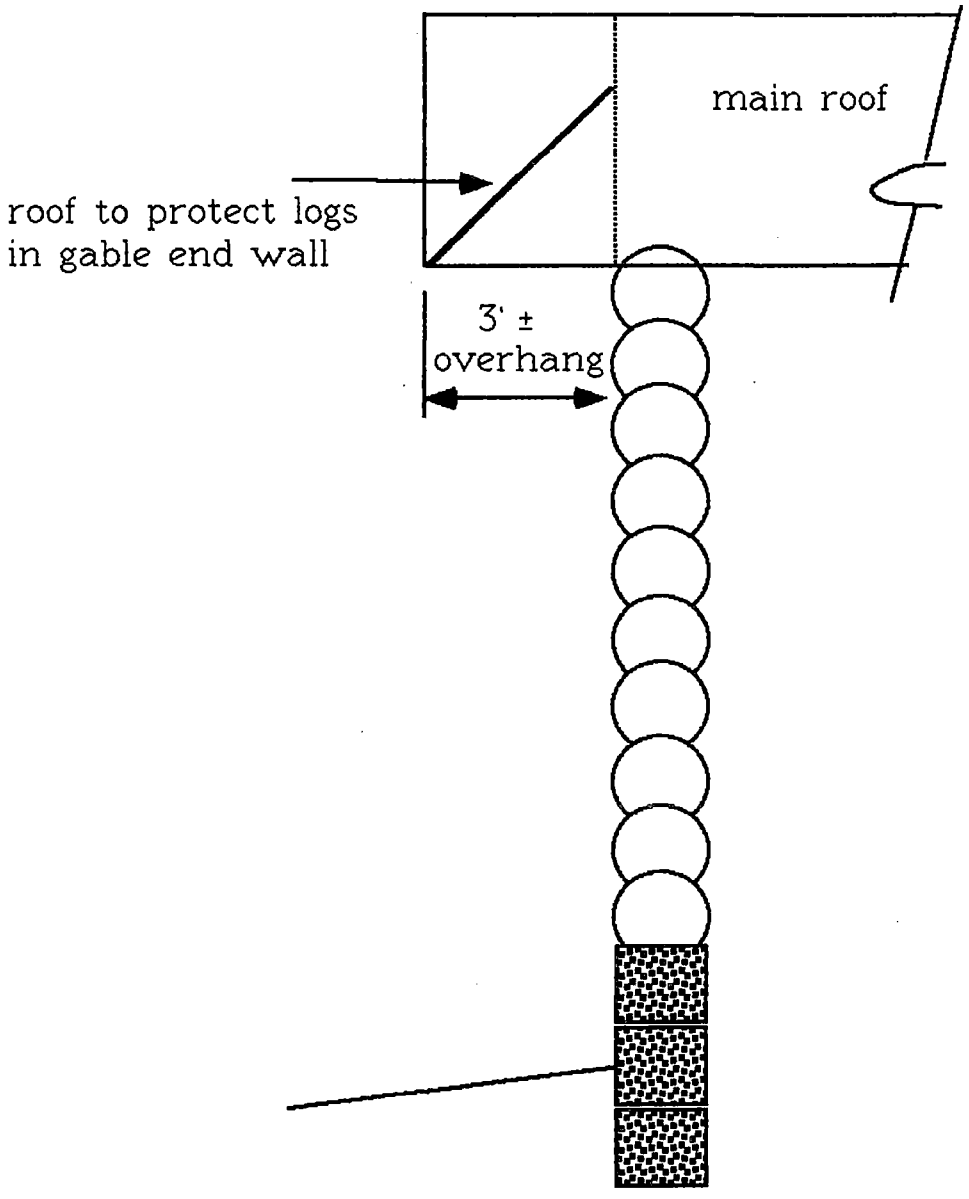

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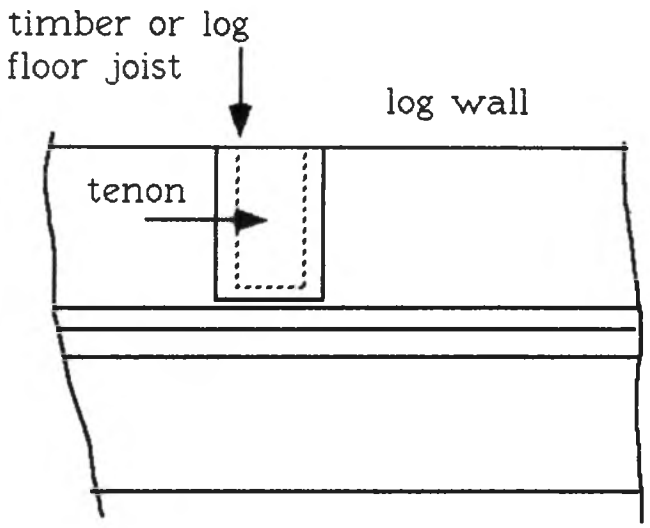
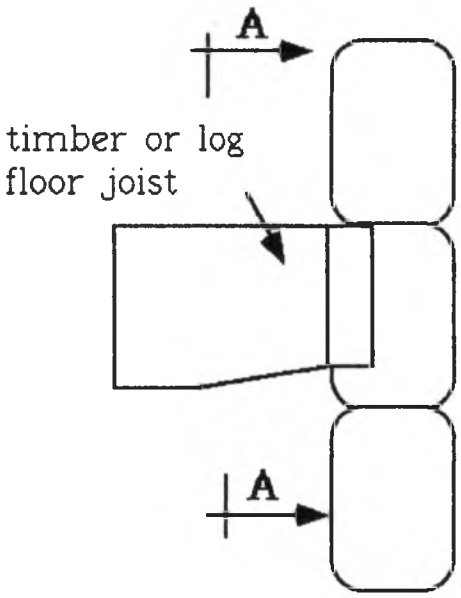
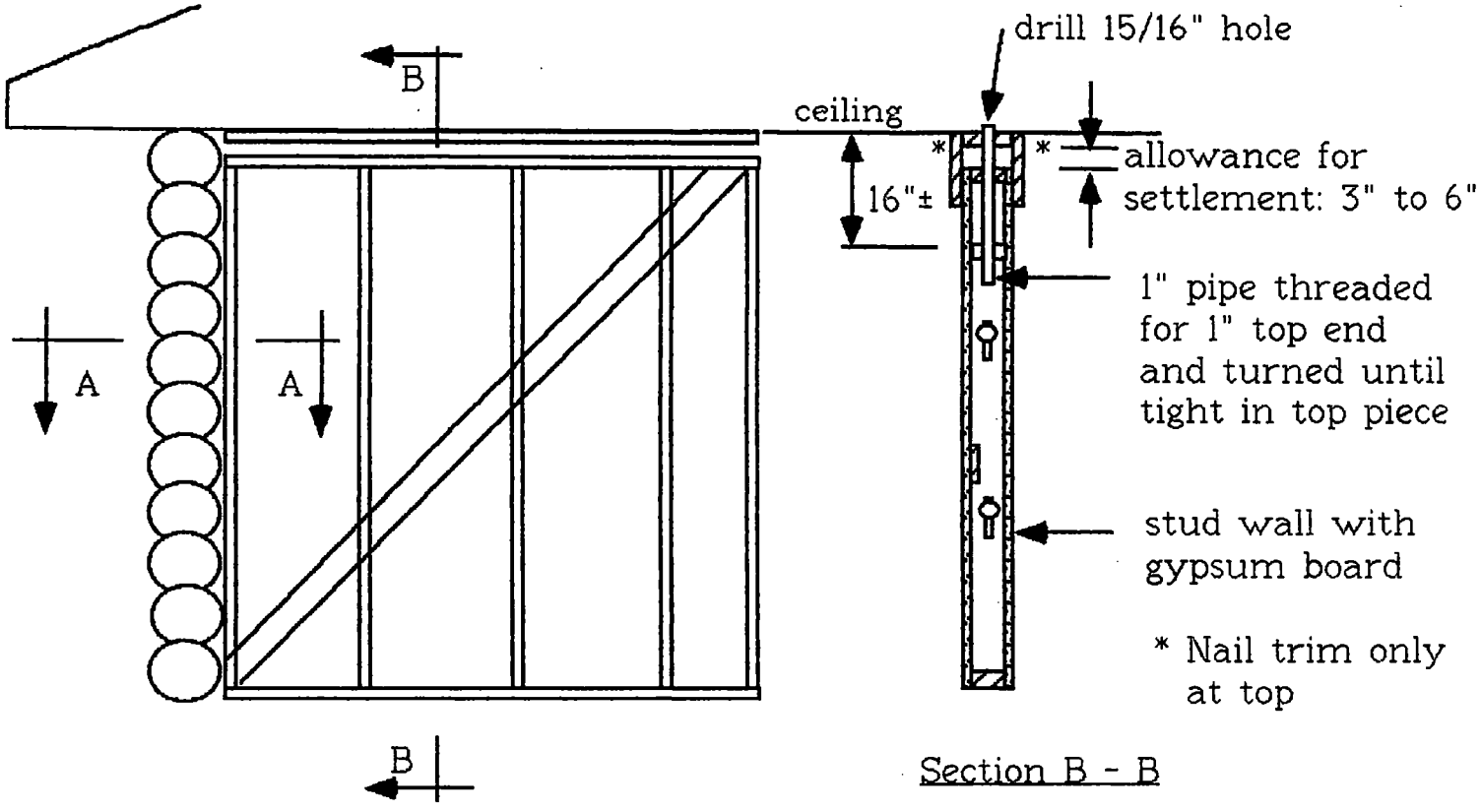


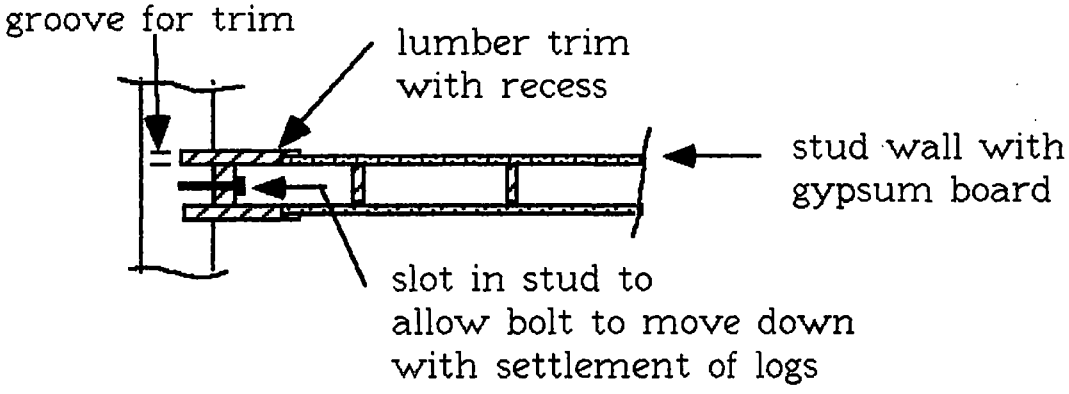
Section A -A



Sketch No. 7

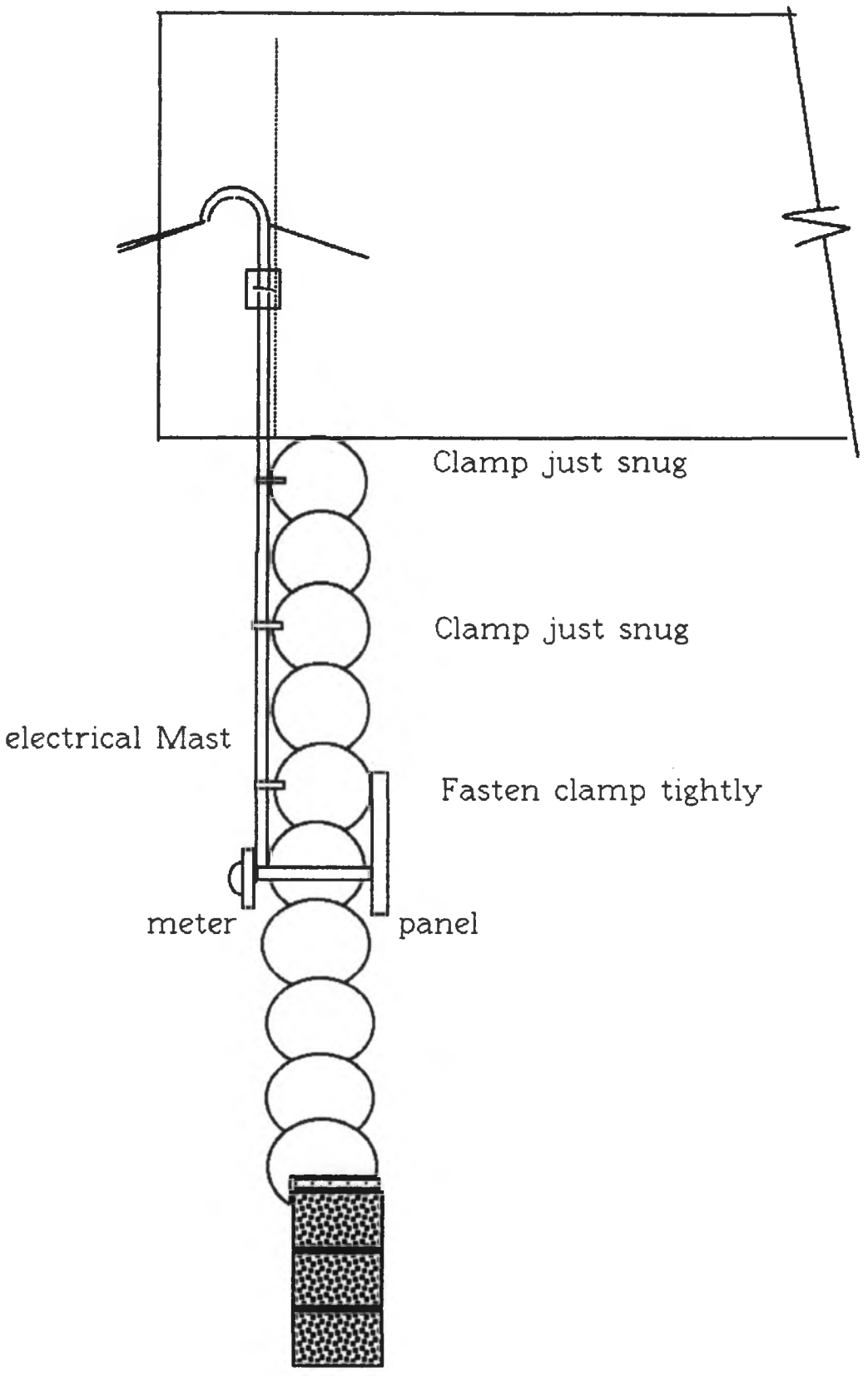


Section B - B



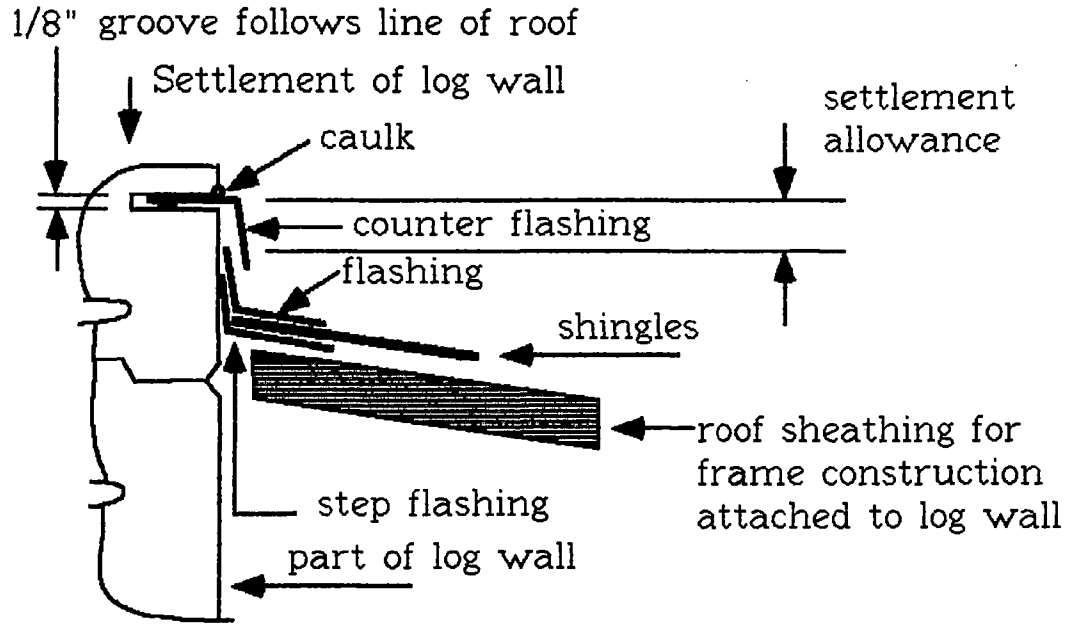
Section A - A

Sketches No. 8 & 9

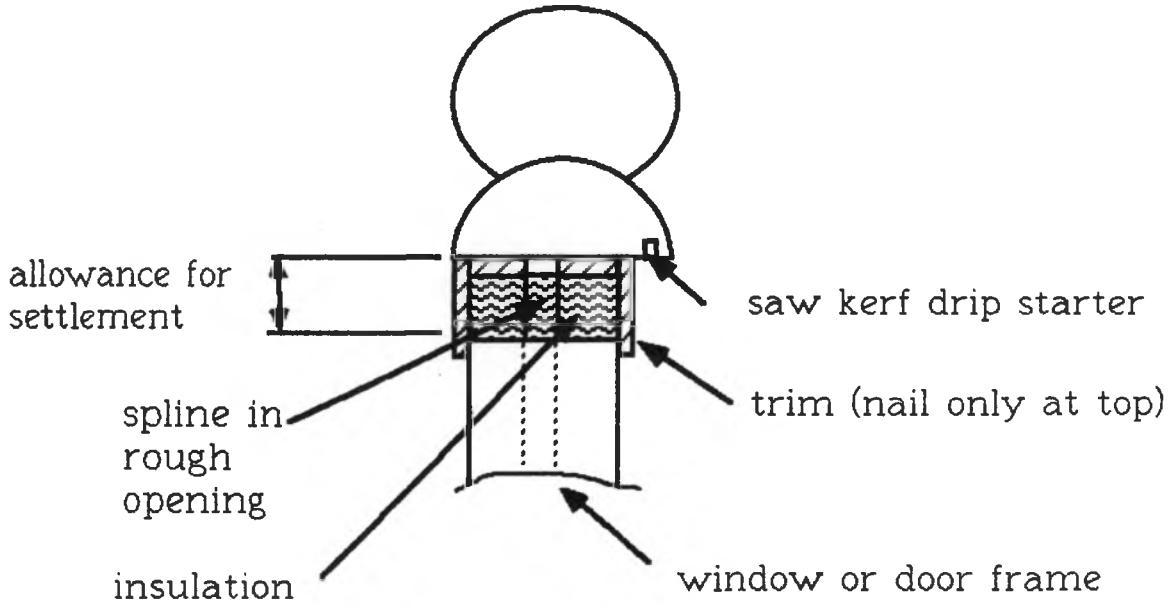


Fastening for Electrical Mast

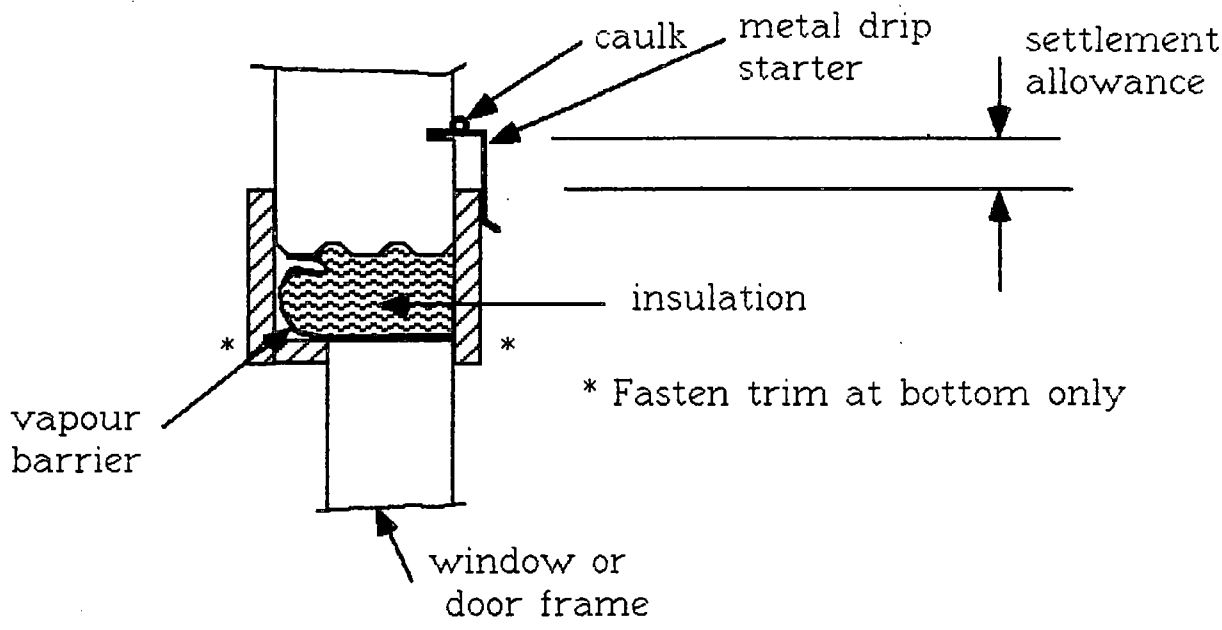
Sketch No. 10



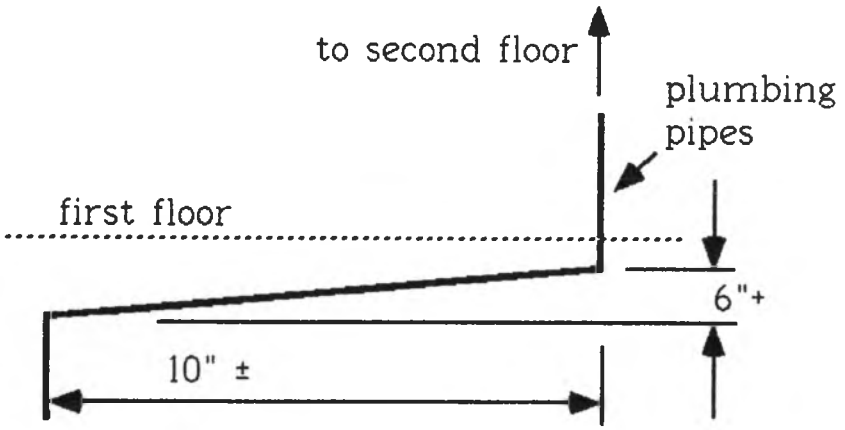
Sketch No. 11 (Flashing Detail)


allowance for
settlement
saw kerf drip starter
spline in
rough
opening
trim (nail only at top)
insulation
window or door frame

Sketch No 12


caulk
metal drip starter
settlement allowance
insulation
*
*
* Fasten trim at bottom only
vapour barrier
window or door frame

Sketch No. 13



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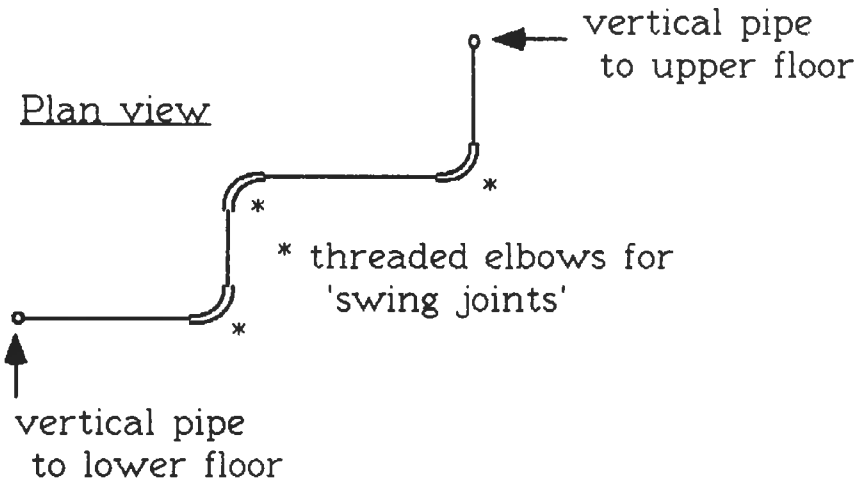

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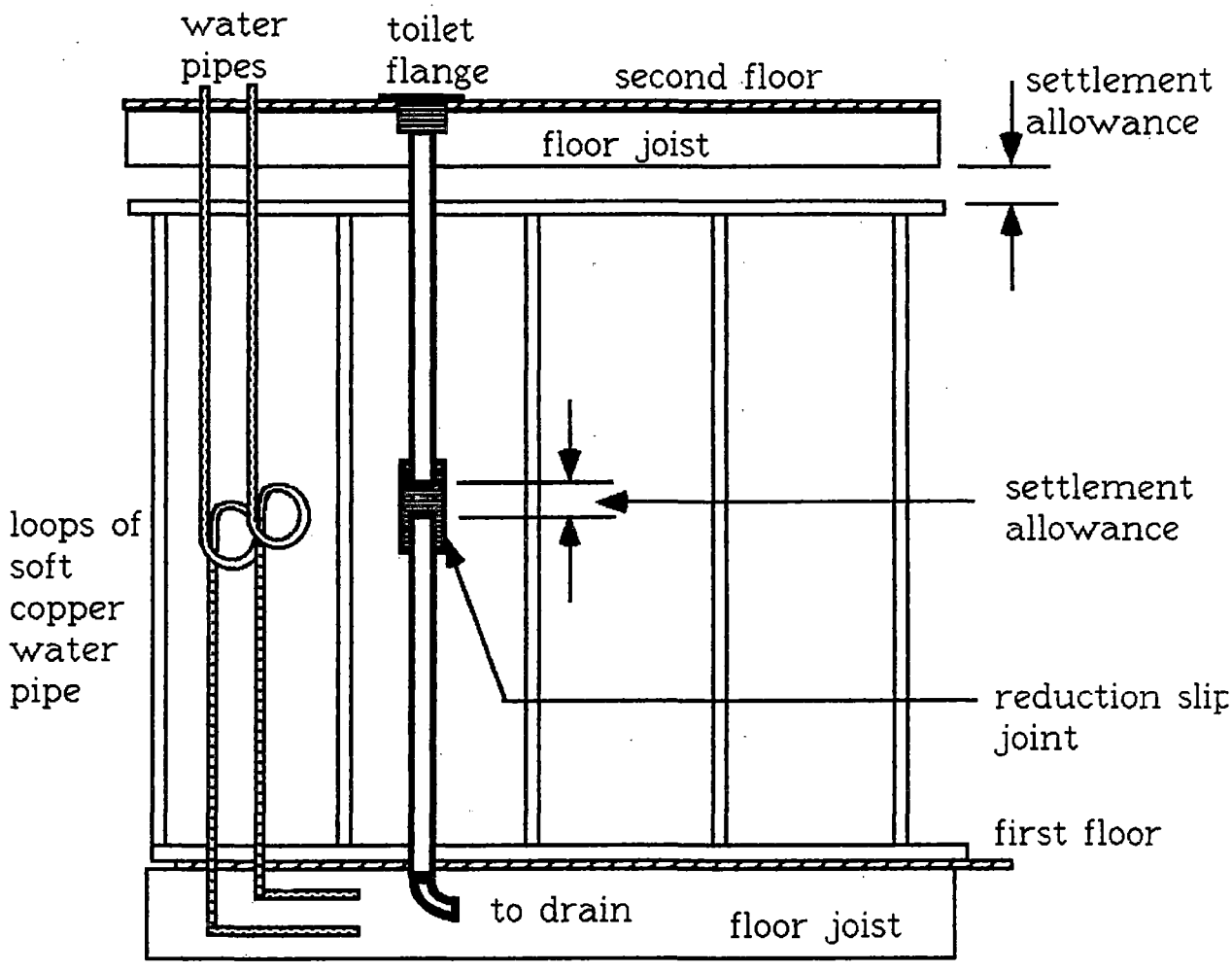
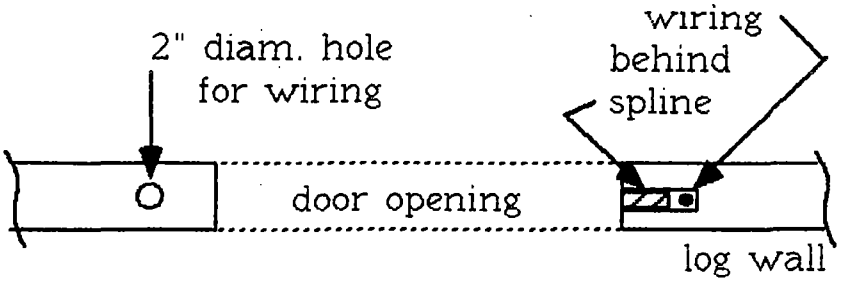
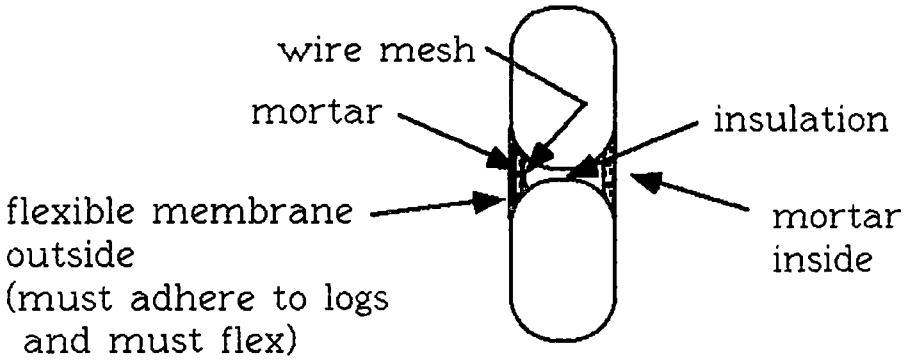

water pipes
toilet flange
second floor
settlement allowance
floor joist
loops of soft copper water pipe
settlement allowance
reduction slip joint
first floor
to drain
floor joist

Sketch No. 16

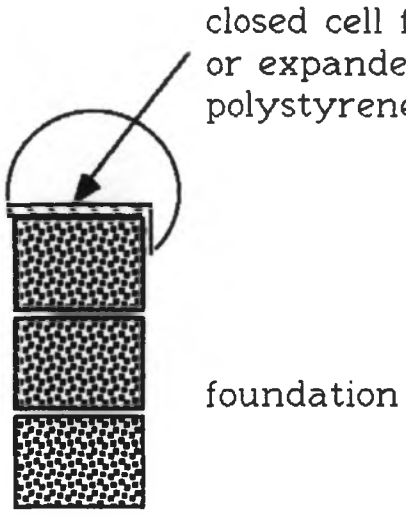


Plan view

Sketch No. 17


wire mesh
mortar
insulation
flexible membrane
outside
(must adhere to logs
and must flex)
mortar
inside

Sketch No. 18



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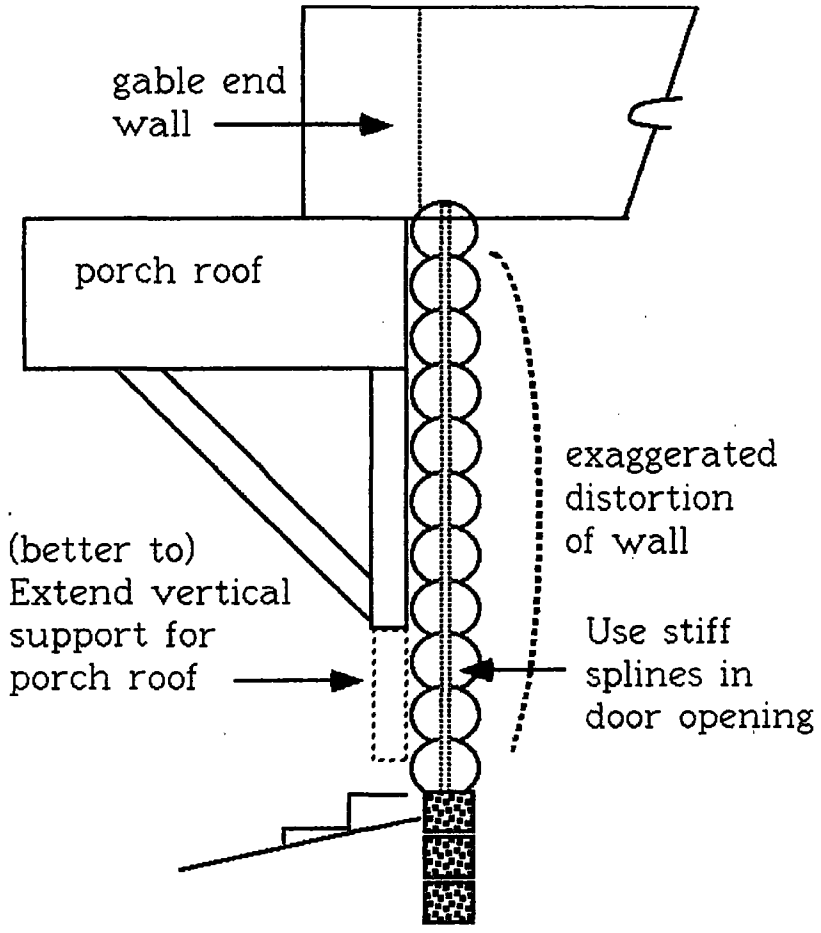
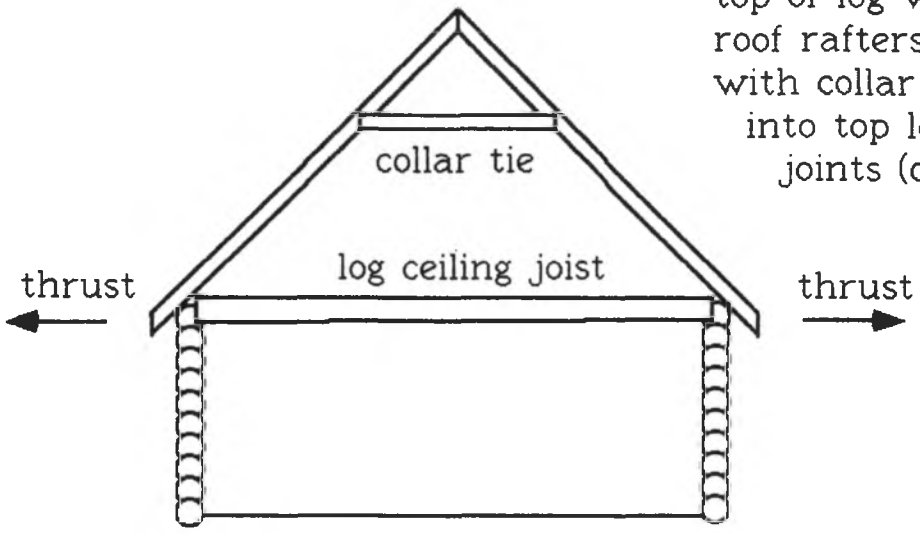
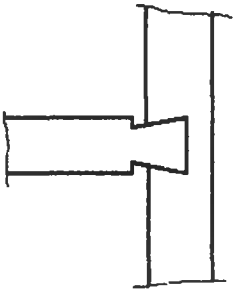

gable end
wall
porch roof
exaggerated
distortion
of wall
(better to)
Extend vertical
support for
porch roof
Use stiff
splines in
door opening

Sketch No. 20

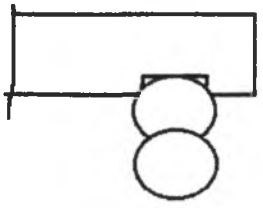
Prevent outward movement of top of log walls due to thrust from roof rafters by tieing walls together with collar ties or ceiling joists framed into top logs of walls with locking joints (dovetail or square notch)



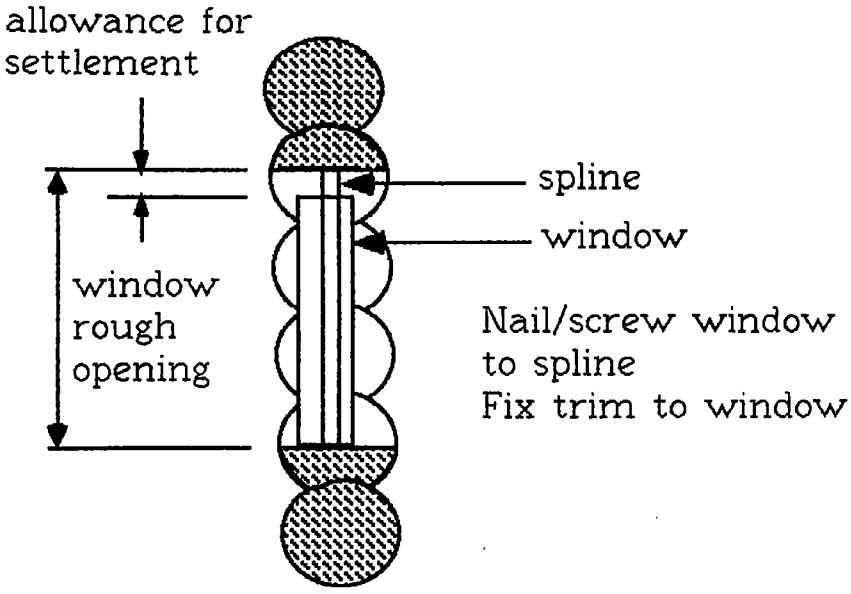
Sketch No. 21



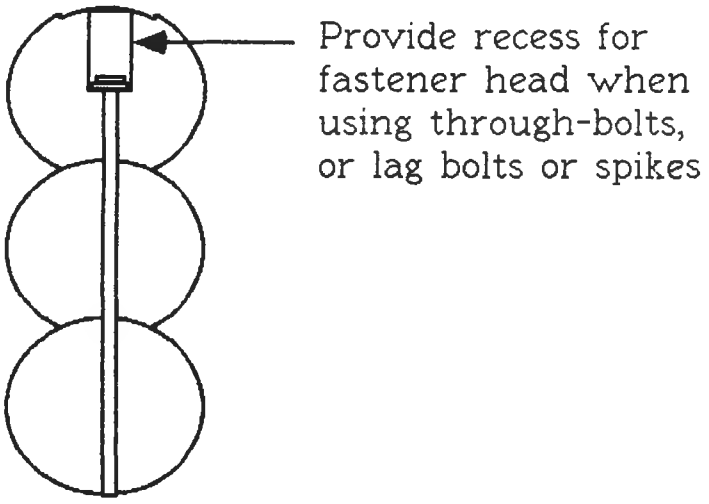
dovetail joint
in plan



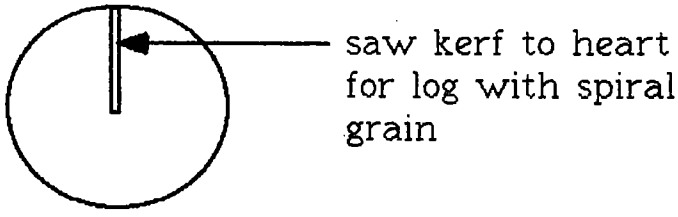
square notch joint
in elevation


allowance for
settlement
spline
window
window
rough
opening
Nail/screw window
to spline
Fix trim to window

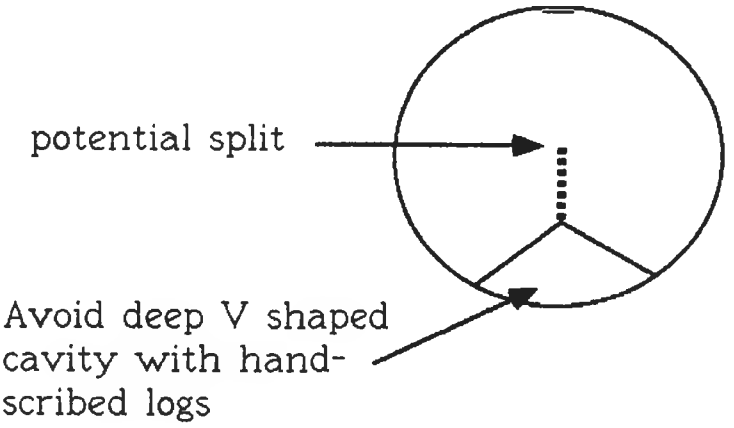
Sketch No. 22


Provide recess for
fastener head when
using through-bolts,
or lag bolts or spikes

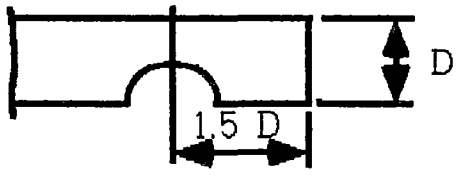
Sketch No. 23



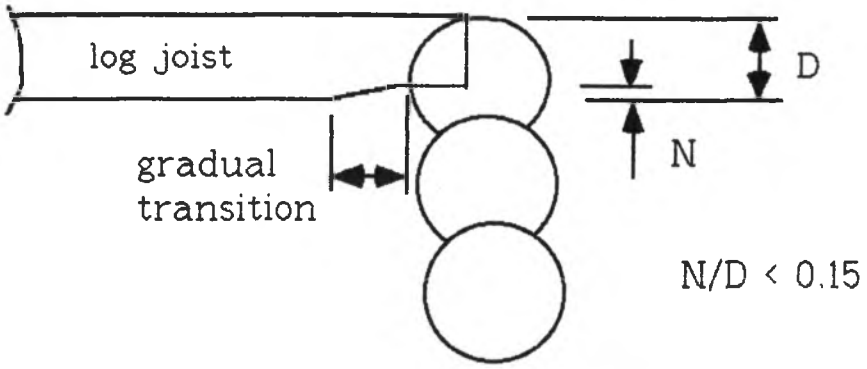
Sketch No. 24


potential split
Avoid deep V shaped cavity with hand-scribed logs

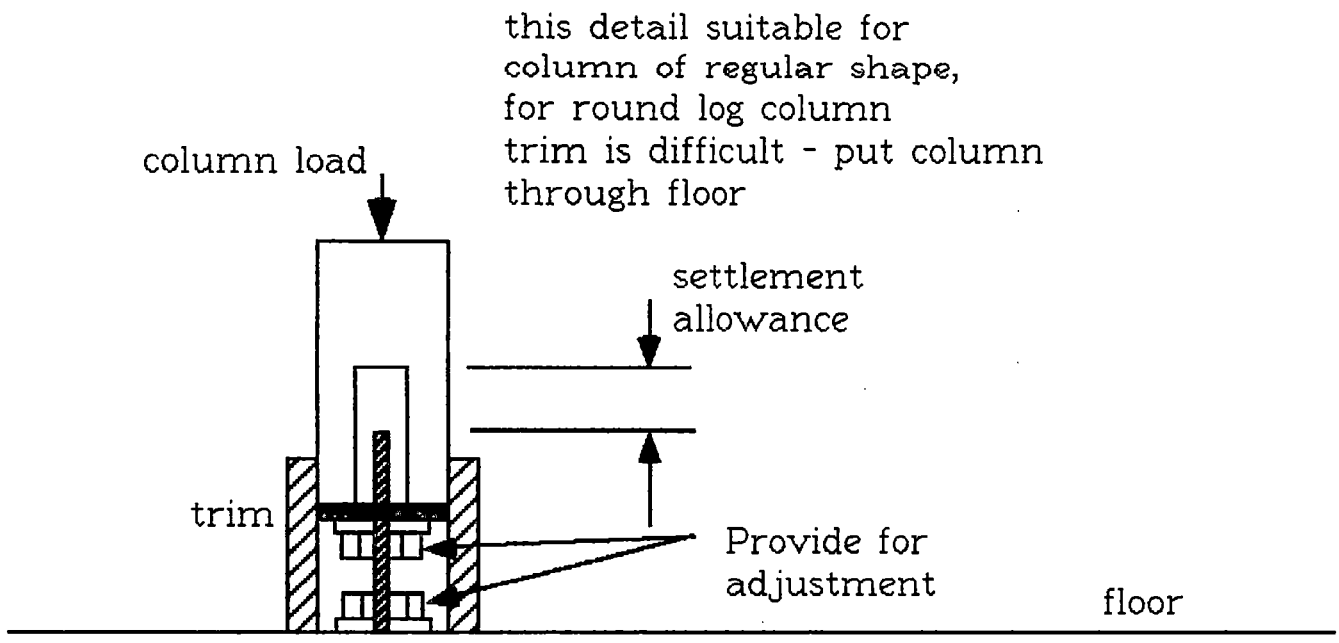
Sketch No. 25



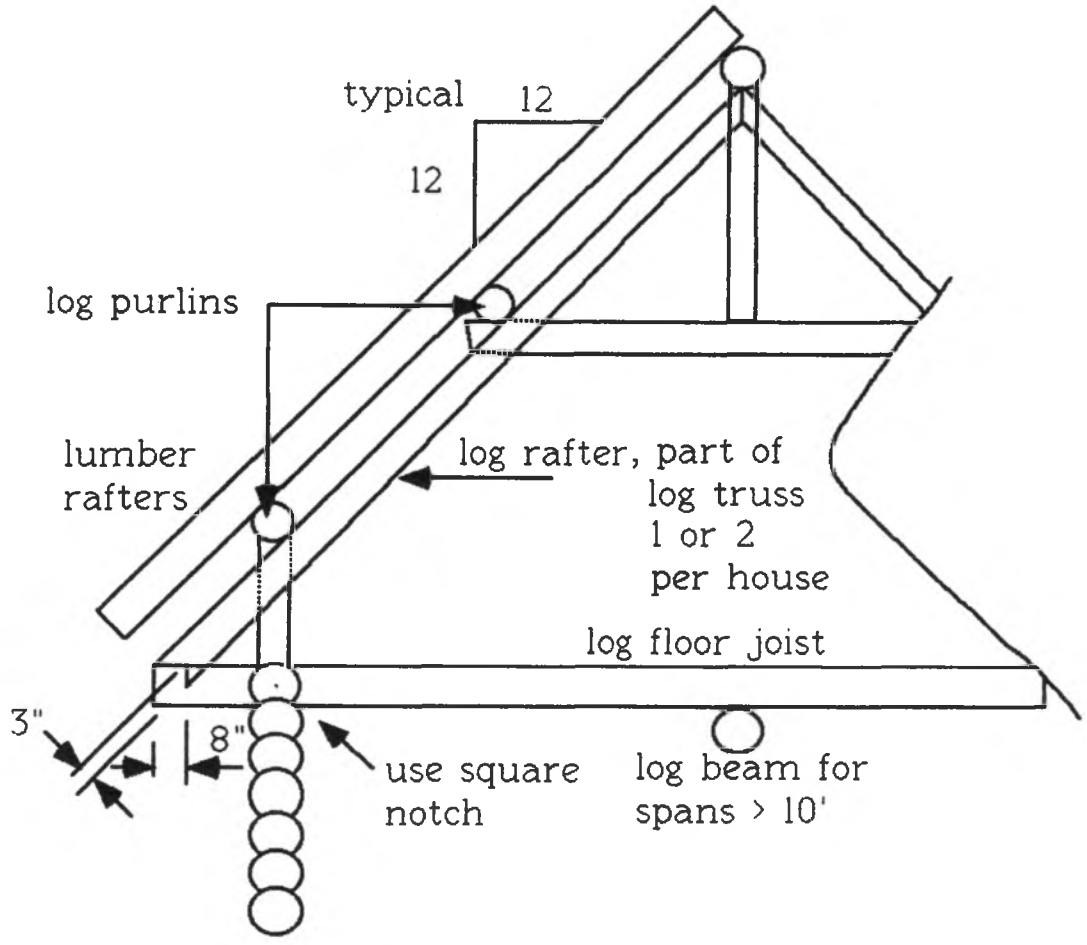
Sketch No. 26



Sketch No. 27


this detail suitable for
column of regular shape,
for round log column
trim is difficult - put column
through floor
column load
settlement
allowance
trim
Provide for
adjustment
floor

Sketch No. 28


typical
12
12
log purlins
lumber
rafters
log rafter, part of
log truss
1 or 2
per house
log floor joist
3"
8"
use square
notch
log beam for
spans > 10'

Sketch No. 29