PREFACE

The Punjab Forest Leaflets were issued by the Chief Conservator of Forests embodying his technical orders. It had become questionable if they had reached all the officials in the Forest Department. It was, therefore, decided to revise and print them as Punjab Forest Manual, Volume III. Any further technical orders can be issued as addenda to this Volume.

2. The orders in this Volume override the relevant prescriptions in the working plans wherever they are contrary to these orders and are the standing orders by Chief Conservator of Forests. They are binding on every member of the staff. It is the duty of such members to make themselves acquainted with them. Any disregard or negligence of these orders would mean disobedience of orders and the official concerned would be proceeded against accordingly.

3. It is suggested that this volume should be translated into Hindi and Punjabi as soon as circumstances permit.

Sialkot:
9th November, 1965.

N. P. Mohan,
Chief Conservator of Forests,
Punjab.
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TECHNICAL ORDER NO. 1

THINNINGS

A.—General

In order to ensure the general application of the principles of thinning in the various types of forest found in the Punjab, which experience has shown to be the best and to ensure continuity of policy in the matter of the times and manner in which thinning should be performed, it has become necessary to lay down standing instructions regarding the conduct of this operation for the guidance of everyone concerned.

2. A thinning consists in lessening the crowded condition of the crowns of the best trees in a canopy so as to favour their development. In the Punjab thinning among crops below 4" in diameter are called “clearings”, while thinning among crops of 4" up to 6" in diameter (usually made semi-automatically with a stick of appropriate length to give the desired average expression) are designated “early thinning”. The principles underlying all thinning operations, however, remain the same.

3. The necessity for thinning has long been recognised; the importance of thinning among the dominant and subdominant and diseased trees having been especially realised; for while the removal of suppressed and dead or moribund trees may have an appreciable effect upon root competition, such removal is distinctly undesirable when the cut material cannot be removed from below the crop without unjustifiable expenditure; since not only is money wasted in felling such material, but the fire hazard is greatly increased by the mass of dry wood lying under the standing crop.

4. Thinnings are made not only to increase increment but also as a measure of fire protection; woods which are well thinned at an early date and which are free from an excess of suppressed and inflammable material, are much less subject to fire damage than unthinned crops.
The degree of thinning will vary with the species dealt with. *D. pendula* always requires a heavy thinning. *P. longifolia* forms a much more open crop than deodar and silver fir hardly requires any thinning at all.

5. Thinnings should commence early and be repeated as often as necessary, subject only to the consideration that inflammable material is not to be left lying on the forest floor. "Clearings" and "early thinnings" must be considered essential in even-aged crops for the establishment of vigorous stately crops and for the encouragement of increment from the earliest age; but, in older crops where material cannot be disposed of without expenditure, true thinnings should ordinarily be postponed until the cut material can be disposed of either free or at a price. However, in areas under concentrated regeneration (e.g. P.B.I. and the youngest P.B. under the Shelterwood System) early and repeated thinnings are so important for the optimum development of the crop that periodical thinnings must be carried out even though the disposal of the cut material involves expenditure of considerable sums of money: such expenditure will undoubtedly be repaid in course of time by accelerated maturity of the crops. However, thinnings in young stands must not be so heavy as to prevent the production of long clear boles when timber production is an object of management.

6. In cases of artificial reproduction, whether by sowing or planting, the number of plants should be reduced to the minimum necessary and their spacing increased to the maximum permissible to obtain the crop required. Thus money is not expended in growing plants which only have to be cut out a few years later in "clearing" or "early thinnings". In the case of deodar, the standard quantity of seed in direct seedings is 10 Lbs per acre and the standard planting distances 6' x 6' in square planting and 12" x 3' in line planting. When patch sowing and transplanting from the patches in the method of stocking adopted, the patches are best made 12" apart in the line from edge to edge, the transplants being put out in the following year between the patches so as to given an espacement in the line of 3" x 6'. The standard in the irrigated plantations is 10' x 6' where 1st thinnings at age 5 can be made and elsewhere-10' x 8'.
7. "Cleanings" should aim at the gradual spacing out of natural seedlings (or sowings where the original stocking has been too dense) until the young trees are spaced approximately 4' X 4' when 6 feet high. "Early thinning" should cease when the sapling crops have an average diameter of over 8", when the espacement should be about 8'.

8. The standard thinning cycle is 16 years but after 8" "early thinnings" stage is over and until the cut material can be disposed of without cost to Government.

9. It is now necessary to consider the standard of thinning to be prescribed in even-aged crops. The Indian classification of thinnings is described in Indian Forest Records, Volume XV, Part I, and every trained officer of the service will make it his business to understand this classification and to be able to carry it out. In cases where crops are thinned for the first time a moderate ordinary thinning, "B" grade, will be carried out. In all other cases up to 20" diameter a heavy ordinary thinning, "C" grade, will be done. Where preparatory fellings are prescribed under the Uniform System, those will, in the majority of cases, consist of a very heavy ordinary thinning, "D" grade; though in a number of cases a "C" grade thinning will be sufficient. The same is equally true of the frugated plantations where the 2nd and 3rd thinnings will now all be of the "C" grade.

10. Turning now to the case of un-even-aged crops managed under the Selection System, it is difficult to standardize thinning practices to the same extent as in even-aged woods. The guiding principles must be the maintenance of a canopy of undulating profile characteristic of such un-even-aged crops (Gayer's line) and all thinnings will be made in favour of the best grown and most vigorous trees of the crop irrespective of age or size. Normally the same grades of thinnings will be applied as have been prescribed for even-aged crops in paragraph 9 above, each cohort of trees being treated on its merits. Great caution must be exercised however, in reducing the number of trees approaching maturity on which the
7. "Cleanings" should aim at the gradual spacing out of natural seedlings (or sowings where the original stocking has been too dense) until the young trees are spaced approximately 4' × 4' when 6 feet high. "Early thinnings" should cease when the sapling crops have an average diameter of over 8", when the espacement should be about 9'.

8. The standard thinning cycle is 10 years but after 8" "early thinnings" stage is over and until the cut material can be disposed of without cost to Government the instructions given in paragraph 8 above must be complied with.

9. It is now necessary to consider the standard of thinning to be prescribed in even-aged crops. The Indian classification of thinnings is described in Indian Forest Records, Volume XV, Part 1, and every trained officer of the service will make it his business to understand this classification and to be able to carry it out. In cases where crops are thinned for the first time a moderate ordinary thinning, "B" grade, will be carried out. In all other cases up to 20" diameter a heavy ordinary thinning, "C" grade, will be done. Where preparatory fellings are prescribed under the Uniform System, these will, in the majority of cases, consist of a very heavy ordinary thinning, "D" grade; though in a number of cases a 2 "C" grade thinning will be sufficient. The same is equally true of the irrigated plantations where the 2nd and 3rd thinnings will now all be of the "C" grade.

10. Turning now to the case of un-even-aged crops managed under the Selection System, it is difficult to standardise thinning practice to the same extent as in even-aged woods. The guiding principle must be the maintenance of a canopy of undulating profile characteristic of such un-even-aged crops (Geyer's line) and all thinnings will be made in favour of the best grown and most vigorous trees of the crop irrespective of age or size. Normally the same grades of thinnings will be applied as have been prescribed for even-aged crops in paragraph 9 above, each crown of trees being treated on its merits. Great caution must be exercised, however, in reducing the number of trees approaching maturity on which the
future yield depends: consequently thinnings among trees
over 30" diameter should not usually be carried out; but
this does not, of course, preclude the removal of suppres-
sed, dead or moribund and diseased trees.

B. -- Practical hints on thinning in coniferous woods

11. The majority of coniferous forests have been
thinned once already. Some unthinned woods are of
advanced age and require thinning urgently and
should have been thinned long ago, consequently the
grade of thinning employed in the hills will be grade C.

12. A thinning to be effective must be of sufficient
intensity to afford to the crowns of the dominant trees
room for development: at the same time opportunity must
not be given to the lower side branches to persist. The
object must be the production of trees with clean boles
and well developed crowns which do not extend more
than one-third down the total height of the tree when
it has completed the major portion of its height growth.
Side branches naturally persist for some time on young
trees but gradually die in close woods with the advance-
ing age of the tree.

13. In clearings suppressed and dominated saplings
must be cut.

14. In chit forests dominated and suppressed trees
must be cut as their retention aggravates the effects of a
forest fire, which is liable to extend to the crowns: a
crown fire kills the trees whereas a ground fire rarely does
much damage. The dominant trees must be so spaced as
to afford ample room for crown development as the crowns
of chit trees will not develop in crowded woods.

15. In doolar woods the retention of some dominat-
ed trees is desirable both because they help to clean the
boles of the dominant trees and because the dominated
trees are able to replace casualties due to snow break
amongst the dominant trees.

16. Suppressed trees should ordinarily be cut when
there is a local demand for them except when they are on
the edge of blanks.
17. In early youth saplings should be thinned to an average spacing of 6 to 8 feet. Forest Guards soon learn this work.

18. Crops should then be left unthinned for ten or twelve years until the lower side branches die in, in order that the boles may furnish timber of high quality. Thinnings should not, however, be delayed unduly as the crowns soon become constricted. Thinnings should then take place at intervals of about 10 years until the trees have completed the greater part of their height growth. At each thinning crowns must be given sufficient space to develop, but there should be no permanent interruption in the canopy, such as would strengthen the side branches. After thinning the branches of neighbouring trees should not touch, but the canopy should close within 3 years.

19. The average spacing between neighbouring trees should be about four times their average girth, a ‘rule of thumb’ method which has been tested for years and which is to be used as a guide to subordinates as to the intensity of thinning required in the first half of the rotation. Naturally the spacing varies in localities of different quality, but the rule is sufficiently correct for practical use.

20. By the time trees have reached or slightly passed the rotation age, when they should be of about 16” to 18” diameter, their crowns should be confined to the upper third or half of the tree. In India, however, the light is much brighter than in Europe and as a consequence the branches frequently persist, particularly when trees grow on steep hill sides.

21. As the trees increase in size the removal of each tree leaves a gap between its neighbours. Consequently at half rotation age the canopy does not close up after thinning for a number of years, if at all. The necessary interval between thinnings increases to a minimum of 15 years. It is thought that an interval of at least 25 years is required in woods approaching maturity. There is no need to fear the development of side branches; the time for forming a clean bole has passed and thinnings afford the trees room to develop large crowns and rapid volume increment.
22. In choosing trees to be left to grow to maturity the vigour of the tree is all important. All suppressed and dominated trees should be cut and vigorous trees with well developed crowns should be retained as they alone are capable of rapid increment. The distance between neighbouring trees after thinning is from 5 to 8 times the girth at breast height.

23. The kail tends to thin itself naturally, but unthinned woods suffer severely from snow break. Early thinnings permit of the strengthening of the dominant trees. The intensity of thinnings is intermediate between that of chil and deodar, but as it is often impracticable to dispose of the cuttings, dominated trees should ordinarily be left unless they interfere seriously with the development of the crowns of dominants. Suppressed trees should be cut whenever they can be got rid of as their retention aggravates the effects of fire.

24. The kail and deodar show very different rates of growth. Kail outstrips the deodar in youth and must be cut back so as to favour the deodar; later on, in life, the deodar easily holds its own.

25. The mixture by single trees is difficult to maintain. The natural effect of thinnings is to convert the mixed forest to deodar. In unthinned woods the kail tends to form a complete canopy below which the deodar is hopelessly suppressed. The object of thinnings is to favour the deodar by the removal of kail suppressing the deodar. Care must, however, be taken not to open out gaps in a forest, and the object of management must be to obtain groups of pure deodar and kail, or of deodar mixed with kail of more or less even height. The mixed character of the crop must be maintained and the average age must not be decreased.

26. When kail trees occur isolated or scattered over compact groups of deodar seedlings the kail trees must invariably be cut out, when of not more than III class size (4'-6' girth): no compact overwood of kail may, however, be cut or the canopy interrupted for the sake of a few suppressed deodar. Special attention is invited to paragraph 26 on "common mistakes in thinnings." The lopping
and girdling of kail, spruce and fir in improvement fellings
is strictly prohibited: the subordinate executing
thinning must make up his mind definitely either to cut out
kail trees over groups of deodar, or to leave them stand-
ing.

27. The sale value of spruce and silver fir is very
low indeed, but for that reason alone they cannot be
in admixture
from the more valuable deodar and kail, kept the ground moist
and favour the improvement in the quality of the locality.
They must be cut out when they suppress more valuable
species capable of development, but must be retained
when they do no considerable harm to deodar and kail or
when they only form a small proportion of the crop. Care
must, however, be taken not to make permanent gaps in
the canopy.

28. Conifers under certain conditions tend to invade
areas occupied by broad leaved trees; and must be favour-
ed in youth by topping the broad leaved trees. Once how-
ever the conifers get their heads free the broad leaved
trees must be retained as a very superior grade of timber
is produced in mixed conifer and broad leaved forest. The
broad leaved trees not only improve the soil and the
quality of the locality but they facilitate the natural
regeneration of mature woods. Broad leaved trees form a
valuable source of local fodder supply which cannot be
neglected; no attempt whatever should be made to ex-
terminate them.

29. (a) Deodar thinnings.—There is a tendency for
Conifers in favourable
localities to grow rapidly and when the thinning is too
light the crops again become very dense in a year or two.
The intensity of thinning in somewhat
must be such that the
plains benefit definitely from the operation and will
not require further attention for the next ten years.

On the other hand crops on poor ground grow slowly
and the thinning must be appreciably lighter than in
crops growing in favourable localities.
and girdling of kail, spruce and fir in improvement fellings
is strictly prohibited: the subordinate executing thinnings
must make up his mind definitely either to cut out
kail trees over groups of deodar, or to leave them stand-
ing.

37. The sale value of spruce and silver fir is very
low indeed, but for that reason alone they cannot be
considered as weeds. When mixed with kail and deodar so
that as to occupy a definitely lower place in the canopy, they
form a most useful admixture as they clean the holes of
the more valuable deodar and kail, keep the ground moist
and favour the improvement in the quality of the locality.
They must be cut out when they suppress more valuable
species capable of development, but must be retained
when they do no considerable harm to deodar and kail or
when they only form a small proportion of the crop. Care
must, however, be taken not to make permanent gaps in
the canopy.

38. Conifers under certain conditions tend to invade
areas occupied by broad leaved trees, and must be favour-
ed in youth by tapping the bord leaved trees. Once how-
ever the conifers get their heads free, the broad leaved
trees must be retained as a very useful grade of timber
is produced in mixed conifer and broad leaved forest. The
broad leaved trees not only improve the soil and the
quality of the locality but they facilitate the natural
regeneration of mature woods. Broad leaved trees form a
valuable source of local fodder supply which cannot be
neglected; no attempt whatever should be made to ex-
terminate them.

39. (a) Deodar thinnings.—There is a tendency for
thinnings to be too light. Young trees in favourable
localities grow rapidly and when the thinnings are too
light the crops again become very dense in a year or two.
The intensity of clearings and thinnings must be such that
the plants benefit definitely from the operation and will
not require further attention for the next ten years.

On the other hand crops on poor ground grow slowly
and the thinning must be appreciably higher than in
crops growing in favourable localities.
Remember the better the crop the faster does it close up.

(d) In natural fores the density of the stocking varies from place to place. The dense portions require thinning but when the person marking the thinning enters the more open portion there is a tendency to take out more trees than are needed. Mistakes arise and it is better not to attempt to thin the more open portion at all. No harm can be done by leaving open portions of the crop unthinned.

(e) Small blanks occur in every forest and must never be extended. If any tree is removed on the edge of a blank the area of the blank is thereby increased. Even when the tree cut is dominated or suppressed its removal permits of the development of side branches of the dominating trees which is not wanted. Consequently do not thin on the edges of small blanks or gaps. For example see diagram No. 1. If tree No. (5) is cut tree No. (4) will develop side branches and the gap between tree No. (4) and (5) will be extended, which is wrong. It is of course correct to remove tree No. (3).

(d) Removal of suppressed trees:—A suppressed deodar, spruce or fir tree does no harm and it should never be cut except when suppressed deodar and kail are wanted by right holder. It is wrong to cut it and let it lie on the ground as it increases the damage from fire. On the other hand it is necessary to cut suppressed chir and kail trees to prevent a fire reaching the crowns of dominating trees. But it is wrong to allow the cut material to remain on the ground. It must be thrown into nullahs or removed outside the forest.

(e) Mistakes are common in thinning mixed deodar and kail woods—see paragraphs 24 to 28 above. The removal of isolated kail above groups of young deodar is very necessary but it is quite wrong to cut kail trees from compact groups for the sake of a few scattered
3 suppressed deodar. III class kail should be cut only when they are wanted by right.

Diagram 1

Jodhpur or are for sale to purchasers. I and II class kail will not otherwise be marked in thinnings. The lopping of kail is strictly forbidden. Lopping is of small value as the kail side branches grow about 9 inches each year and soon again cover up the smaller deodar. The diagrams 2 and 3 should be studied.

Diagram 2
Diagram 3

K—Kail
D—Deodar

In Diagram 2 cut all the kail to favour the group of deodar.

In Diagram 3 do not cut or lop any kail to favour the few suppressed deodar.
TECHNICAL ORDER No. 2

NATURAL REGENERATION OF CONIFERS

Only the conifers of the Punjab will be considered in this order.

2. Successful regeneration of a forest crop depends upon four factors, namely: (1) soil, (2) light, (3) moisture, and (4) grazing. All these factors are within the control of the forester within certain limits.

3. The adverse effect of an excess of undecomposed coniferous litter in many parts of the world has been widely commented on in forest literature and experience has simply demonstrated that this adverse effect is operative in the coniferous forests of the Punjab. The removal of much litter for the bedding of cattle in Upper Kulu has always been attended with excellent regeneration.

4. Excessive grazing by hardening the surface of the soil may entirely inhibit regeneration. Illustrations of this fact can be seen everywhere where the forest adjoins large villages and where no closure has been made.

The soil will be in a suitable state for regeneration when the physical, chemical and biological conditions are all favourable. It is bad forestry so to manage forest crops that the soil conditions are rendered unfavourable for natural regeneration, thus necessitating expensive artificial regeneration operations, which could be avoided by proper silviculture; it is the business, therefore, of the forester so to conduct his operations that the maximum amount of regeneration is obtained by the ordinary processes of nature.

5. Little can be done to alter the chemical composition of the soil. The forest soils of the Punjab Himalaya are capable of producing one of the quality classes of pine, deodar or fir, provided that the factors of the locality other than chemical permit of this; and apart from soil acidity, which is of utmost importance in the spruce and silver fir forests (a brief description of the fir regeneration
6. The physical condition of the soil, more particularly proper aeration, is of very great importance to forestry. After the completion of the first regeneration, felling all fallen refuse together with any other undesirable rubbish will be collected into heaps and burnt as a routine measure. Hoeing with the propped vine hoe may be necessary in order to put the soil into suitable condition, but this treatment is not usually required.

6. Nitrification is the most important of the biological processes in the soil. Nitrification should be active; this activity may be assumed in the presence of nitrophilous plants such as Epilobium, Indigofera, Desmodium and raspberry.

Much has been learnt regarding the significance of the plants comprising the ground flora in gauging the suitability or otherwise of the soil conditions for obtaining regeneration. Where plants such as Strawberry, Amilla, violet, ground ivy, maidenhair fern, predominate in the ground flora it may be accepted that all the factors of the locality are favorable to natural regeneration; while, on the other hand, Iris, Balsam, Strobilanthes, Eucalyptus and Spirea, Sorbifolia are dominant in the ground flora conditions are quite unsuitable and often such conditions are unrelieved. Regeneration will only be obtained with difficulty, if at all. The work of Professor Gjeldner as set forth in his "Theory of forest types" should be studied; also two papers on "regeneration of deciduous forests" and "regeneration of fir forests" by Mohan, Silvicultural Conference, 1939.

7. In practical operations the term "light" is considered to include not only light as measured by a photographic exposure meter but also the insidious factors of those soil and moisture conditions which are directly caused by fellings in the forest crop for the purpose of admitting light to the soil. By regulating the intensity of such fellings the temperature and moisture conditions of the soil are altered and consequently the condition of the soil.
and the soil flora. For germination neither the Douglas nor the blue pine make heavy demands upon light, while the silver fir will germinate in and probably prefers for this purpose, shade. The Chir pine, on the other hand, will germinate under, and possibly prefers for this purpose, exposure to direct light. Subsequent to germination a want of sufficient light will under normal circumstances entirely destroy Douglas seedlings, though in the somewhat abnormal conditions prevailing in Douglas forests of the dry situations, protection from the direct light and heat generated by the afternoon sun is essential to the survival of Douglas seedlings. A deficiency of light retards the growth of and often kills blue pine seedlings, while Chir pine seedlings demand full light except at the lowest limits of their natural zone. Spruce seedlings approximate in their demand for light to the Douglas, while silver fir seedlings will stand a very considerable degree of shade over a period of many years without permanent deterioration.

8. Moisture is very largely dependent on light, consequently the importance of side shade and the necessity in the dry zone, and on all but exposed slopes, of starting felling operations, at the top of the forest and progressing down hill is paramount. On the other hand, excessive moisture in a locality under regeneration may often be decreased by the admission of more light than would usually be admitted; though this does not, of course, apply where the excessive moisture is due to water-springs and streams.

9. Fir has been falling to regenerate itself and this particular problem has been engaging attention for quite a long time. Factors immeasurable to fir regeneration are, heavy accumulation of humus, accumulation of fallen refuse, thick growth of weeds and shrubs, heavy opening of the canopy, infrequency of good seed years, heavy uncontrolled grazing (or even light grazing in spring) and bad drainage.

A good deal of experimental work has been carried out by the Silvicultural Research Division to tackle the problem and it has been established that:

(a) Exposure of mineral soil (or in other words removal of humus either by careful burning or by scraping) is essential.
(b) Weedings are very beneficial.

c) Fir regeneration is easier to obtain under the shelter of hard-woods.

It is now being increasingly recognised that an intermediate stage of broad-leaved trees between a mature fir forest and young fir regeneration is essential. A natural method would be to grow alternate crops of hard-woods and to let the fir come in naturally afterwards. With the closure period restricted to 30 years, and on account of slow growth of silver fir seedlings, discovery of quick growing hard-woods and some conifers was taken in hand. A large number of exotic and indigenous species are under trial e.g., Populus monophylla, Populus nigra, Populus alba, Populus ciliata, Acacia indica, Pinus raddeana, Pinus sylvestris, Thuja plicata, Larix sibirica and Larix leptolepis, Cupressus torulosa and Cupressus. Of these the popular species seem most promising, but 30 years closure period still seems to be too little for both the intermediate stage and regeneration period and efforts will have to be made to get this limit extended.

By and large the problem of fir regeneration revolves round the removal of thick undecomposed layer of humus. Whether this is effected by burning or by scraping or by permitting of buffalo grazing and potato cultivation, or by the introduction of hard-woods is immaterial. The limiting factors ultimately are the time and money (Kuhl Working Plan by Aggarwal should be studied carefully wherein this problem has been discussed in detail).

10. It is evident that the manipulation of the canopy of the forest crop has most important results on the composition of the soil, the light reaching the ground, the temperature and the moisture content of the soil. In all methods of regeneration under a shelterwood the seeding falling is a compromise between:

1) the necessity for retaining sufficient trees to maintain the soil, light and moisture conditions necessary to successful regeneration and to give an ample crop of seed,
(2) the necessity of removing all cover not absolutely necessary so that the subsequent fellings of the overwood will do as little damage as possible to the young regeneration.

(3) the prevention of rank weed growth.

11. Another factor to which prominence has been given is root competition between the mother tree and the regeneration. Experimental plots were laid out in deodar forests of Kulu Division to study the effect of elimination of root competition (by trenching) on regeneration. Though the plots were not laid out statistically yet, broadly speaking, it was apparent that trenching had beneficial effects on survival and height growth of deodar seedlings. The extension of such an experiment on a large scale in practical forestry is obviously out of the question; but the results of the experiment emphasise the importance of the heaviest seeding felling compatible with the principle of conserving all favourable locality factors enunciated in the preceding paragraphs. They also point to the advisability of so tending the new seedling and sapling crop obtained in regeneration areas that each plant has sufficient freedom from unnecessary root competition to grow to the highest standard of vigour compatible with the quality of the locality. While root competition may not be of much consequence in areas with a monsoon climate it will certainly operate in the dry zone where the fullest utilisation of the small amount of moisture available by the crop of the future is a matter of paramount importance. The whole technique of regeneration is, therefore, dependent on carrying out the seeding felling on correct principles.

12. Experience proves the necessity of emphasising the fact that in the Punjab coniferous forests as they exist today it is not always necessary to delay the commencement of the regeneration of an area until some sort of felling has been made. Many forest crops, particularly chir pine crops are naturally sufficiently openly stocked to permit of the establishment of a great deal of regeneration without the felling of a single tree. All that is required for the regeneration of such areas is closure against grazing and grass cutting and perhaps a proper manipulation of...
the undergrowth. The importance of this aspect of regeneration work in the Punjab forests cannot be too strongly emphasised. Having drawn attention to this important point in practical forest management in the Punjab, the method of carrying out seeding fellings is dealt with in the next 3 paragraphs.

Seeding fellings

13. Professor Troup in his monograph on *Pinus longifolia* writes as follows:

"The chir pine is one of the most light demanding of species and under favourable conditions the more light admitted the more successful and complete will be the regeneration. It may be said that in ordinary favourable circumstances 5 to 8 seed-bears per acre are ample for effecting regeneration; that a greater number are not only unnecessary, but may even be detrimental to the establishment of a healthy young crop. This statement, however, should not be taken to apply universally. Thus on hot slopes where the soil is stiff and the seedlings are liable to suffer from insolation, protective shade is essential; and the demand for such protection may outweigh the demand for light. There are instances in the "Ravalspindi Division where the slopes are hot and the soil is clayey, of good reproduction establishing itself under an almost complete canopy. We may, therefore, qualify the general statement made above by saying that where protection against drought is necessary the number of seed-bears per acre may have to be increased very considerably."

It may also be stated that on southern slopes as a rule a larger number of seed-bearers is required than on northern aspects. All the experience has confirmed Troup's opinion. It must be remembered that some of the mother-trees invariably die of isolation and that only large crowned mature trees produce regeneration. It is, therefore, laid down that-(1) not less than 8 mother-trees per acre are to be retained.

*Ravalspindi Division is now in Pakistan.*
only large crowned mature trees are desirable as mother-trees.

(2) only straight fibe trees that are above average in crop yield are to be kept.

An initial spacing of 70-90 feet apart will fulfill all the required conditions when the factors of the locality are average for conifer pine; but the necessity of variation in treatment when the factors are adverse must never be lost sight of.

14. The deodar and the blue pine are commonly associated together and their regeneration is generally carried out simultaneously. The deodar is less of a light-demanding tree than the blue pine. The standard specification in the seeding setting is to leave a space of one crown width between the mother-trees.

The width of the crown of an average blue pine mother tree is 30'-37'; leaving a space of one crown's width between the trees will therefore give a spacing of 60'-70' or 12-14 trees to the acre which will in future be taken as the standard average spacing for blue pine. Wide spacing down to 5 trees per acre has been attended with disastrous consequences in some of the valuable forests.

Deodar has a narrower crown than blue pine, and the standard distance for the mother-tree is 50'-60'-.a distance which has given excellent results in the Punjab. This will give 20 trees to the acre.

All seed-bearers of both deodar and blue pine must be well developed trees of past middle-age and not mere poles which are useless for the purposes of regeneration. Remembering that certain casualties always occur among the mother-trees and that caution in opening the canopy is always desirable, it is laid down that the minimum numbers of well grown mother-trees to be kept in seeding setting are deodar 20 and blue pine 12.

15. The regeneration of spruce and silver fir has not yet been standardised. Spruce will, however, require almost if not quite, as much light as deodar, while silver fir requires fairly heavy shade for regeneration.
The spruce has a much wider crown than the silver fir and the same standard spacing of one crown’s width will apply to both these species, giving for the spruce 16–20 trees and for the silver fir 30–36 trees to the acre.

16. It is necessary to consider also the quality of the mother-trees from which will be derived the next crop. The opinion held by many foresters of repute, that the characteristics of the mother-trees are transmitted to their offspring, has been amply proved by recent research. Champion has shown that twist in the pine is hereditary and is transmitted through the seed. The importance of selecting healthy vigorous mother-trees free of defects, of good form and mature age is therefore manifest.

17. The importance of growing mixed crops must be impressed on all forest officers. In particular, pure blue pine crops are most undesirable on account of fire hazard, while a mixture with more shade-bearing conifers such as silver fir and apricots has the great advantage of assisting to close the boles of the pines on which branches persist for a very long time till all but the densest pure crops. Thus a mixture of deodar or silver fir or spruce is most desirable, especially of deodar which is more resistant to fire than blue pine and reduces the amount of inflammable litter on the ground. Apart, however, from particular examples, all mixtures, including the mixture of conifers with such broad-leaved trees as oak, maple and birchberry are to be preferred to pure crops, where conditions are such that it is possible to grow a mixed crop and the promiscuous cutting out of so-called inferior species is not permitted.

18. Under existing economic conditions the only tree which should be artificially introduced in pure crops is deodar, in the case of other trees mixture must depend, for the present, upon natural seedlings. Thus artificial mixtures will only be aimed at in the deodar blue pine zone and under favourable circumstances in the spruce or silver fir zone. For the purpose of introducing deodar in mixture the patches of burnt selling refuse will be sown up and surplus plantations transplanted when big enough. A percentage of 25 to 30 per cent. of deodar in mixed crop is sufficient.
19. Excessive grazing and grass-cutting is always harmful and may in some cases be injurious in areas under regeneration. Light grazing may do no harm and may in some cases be beneficial, but in areas brought under regeneration, rights to grazing and grass-cutting should always be suspended, where legally possible, by closure under the Forest Act. The grazing is then under the Divisional Officer's control and he can open and close as he may be expedient in the interests of forest work as explained in Technical Order No. 313. Once grazing and grass-cutting can be permitted without detriment to the young regeneration, the area can be opened for these purposes at the discretion of the Divisional Officer. This will reduce the fire hazard, a matter of vital importance, especially in the case of ehre pine.

30. As a result of closure, with or without fellings, Tending and Natural regeneration will appear with the full growth of seed from the trees. The other trees and this will be tended as required and supplemented to the extent necessary by sowing and planting in accordance with Technical Order No. 4. The importance of a proper mixture of species is again emphasised.

The standard routine tending operations in regeneration areas are:

(i) Collection and disposal (generally by burning) of falling refuse. Technical Order No. 6.

(ii) Weeding of excess under-growth.

(iii) Cleaning of dense natural regeneration with a view to spacing young plants about 3'-4' apart.

(iv) Cleaning sometimes called early thinning with a 4' stick, in young sapling regeneration, with a view to giving the best saplings an environment of between 6'-8' and 8'-10' according to size.

(v) A 18' grade thinning in young pole crops retained as part of the new crop.

In particular cases, other tending operations may be required and forest officers will use their discretion in applying them; the standard method must, however, never be neglected.
21. Secondary fellings will be the next operation necessary. Their number is never prescribed and they are carried out at the marking officer's discretion. The number of secondary fellings should not be more than is really necessary. The final felling should be deferred in the case of chir pine until the young crops are 6' high and has been burnt departmentally and in all cases the final felling should be deferred so that the mother-trees may put on the maximum increment. The final felling may even be delayed to a subsequent period always subject to the proviso that the young crop is not suffering thereby. Before the final felling is made the young crop should always be of sufficient age and height to permit of logging and sawing being carried on below its canopy and not on top of it. Many instances have occurred where the final felling was unduly hurried on to the detriment of the young crop and the loss of very valuable increment.

22. The attention of all members of the executive staff is drawn to the necessity of understanding and carrying out the correct technique of natural regeneration as laid down in this order which may be summed up as:

(1) correct felling in the overwood.
(2) correct treatment of the soil.
(3) regulation of grazing and grass-cutting.

If these instructions are properly carried out the difficulties of obtaining regeneration will be minimized.

23. Finally, it is necessary to impress most strongly upon all officers that working plans for the coniferous forests in the Punjab are not based upon purely text-book and theoretical silvicultural systems. It is, therefore, of the utmost importance that working plans should be thoroughly studied and understood before any regeneration markings are actually made.

It is further necessary to emphasise the fact that no marking officer can depart from the principles of management and the methods of treatment prescribed in working plans unless and until the plan has been duly amended by the authority who gave technical approval thereto, namely, the Chief Conservator of Forests.
Even where methods of concentrated regeneration are prescribed in working plans, it is to be remembered that the Punjab coniferous forests are under a process of gradual conversion from the un-even-aged selection type to more or less even aged woods characteristic of the uniform system and its various modifications. Consequently, recent working plans embody radical modification of the block methods by which all marking officers are bound, whatever their personal views of the suitability of such modifications may be. In particular attention is drawn to two modifications of the standard uniform system which appear in the vast majority of Punjab working plans dealing with coniferous forests, namely—

(i) the retention of pole crops as part of the new crop.

(ii) the intentional prescription of a considerable degree of irregularity in areas under conversion to comparative uniformity.

In connection with modification No. (i) it must be clearly understood that the diameter fixed for retention applies to the diameter at the time of the introduction of the working plan. Consequently once pole crops have been retained at the first (or seeding felling) marking in a regeneration area no future marking can permit of the regeneration of such pole crops merely because the pole crop is of greater diameter than that fixed in the working plan. It follows that when seeding fellings are delayed for a considerable time after the introduction of a working plan the marking officer is at liberty, and indeed, should, raise the diameter limits to cover the increase in diameter put on by trees since the plan was prepared. Experience has proved that it is most necessary to draw forcible attention to this point as many regeneration areas have been seriously spoiled by misunderstandings in the past.

As regards modification No. (ii) the irregularity aimed at covers two circumstances: firstly the retention of mature trees even beyond the period of regeneration in order to grow some selected trees to large size and secondly to maintain pole crops retained as part of the new crop
in the degree of un-even-agedness which they have naturally attained. Such pole crops will, probably in the majority of cases, contain a larger or smaller proportion of trees above the diameter fixed for retention; but it is bad forestry, which is strictly forbidden, to remove such trees with disregard to the silvicultural requirements of the crop as a whole. Pole crops retained will, only be thinned in the manner prescribed for other pole crops outside regeneration areas in Technical Order No. 1, that is to say thinnings in the retained pole crops will be in favour of the best grown and most vigorous trees of the crop irrespective of age or size and bearing in mind the principle of Guyer's line. Here again experience has proved the necessity of bringing this point prominently to the notice of all marking officers, and it must be clearly understood that any departure from the principles now laid down will be considered deliberate and unjustified departure from the fundamental principles of management laid down for the Punjab.
TECHNICAL ORDER NO. 3

NURSERY WORK

In every well-managed division, nursery grown stock
is required to plant up failed places in natural and
artificial regeneration, to introduce valuable species like
Birch or to increase its proportion in a mixed crop; to
fill in blanks or to re-stock burnt and clear-felled areas,
and landslips etc., and to satisfy the requirements of plants
for the National Tree Planting festival—the Van
dahakova. Good forest nurseries either permanent or
temporary are, therefore, absolutely essential for successful
forest management.

2. Nurseries are of two kinds, permanent and temporary. Permanent nurseries must be formed when large
areas of forest have to be stocked artificially. Temporary
nurseries are formed where natural regeneration is ex-
pected partially to re-stock felled areas. Permanent
nurseries have in recent years largely given place to sow-
ings in patches in situ and from the patches transplants
have been put out in the neighbouring forest. Without
permanent nurseries it is, however, impossible to cope
with large blank areas, burnt by extensive forest fires, or
with the extensive shelter wood fellings of modern working
plans.

3. It is essential that areas under regeneration be
completely and rapidly re-stocked and for this purpose an
adequate supply of vigorous plants must be raised in
nurseries. But when doing this, it must be remembered
that good nursery work is expensive and, therefore, it is
a great waste of money to produce nursery seedlings and
transplants which cannot be utilized. The importance of
good organized nursery work cannot, therefore, be over-
emphasized. The following instructions standardize the
technique of nursery practice and it is hoped that in future
nursery work in the Punjab will be so planned and carried
out that it will be a credit to the Forest Department.

4. Lack of organization is one of the chief defects in organization
nursery work. In the first place, it is essential to know
what areas in the scheme of regeneration should be stocked artificially by planting and what species will be used. When this is done, it can be decided what acreage can be conveniently planted up annually and what number of plants will be required for this purpose. The species, class of stock, whether shedding or transplant, its size and age, and the number required annually for planting, are for the Divisional Forest Officer to determine. This prevents great losses through raising wrong species, or the wrong class of stock, and is a check against growing more than is needed at one time and too little at another. Arrangements should be made to raise approximately the requisite number of plants year after year.

5. A register should be maintained for each permanent nursery. This should contain a detailed plan of the nursery and show after actual count by the Range Officer once a year, say in April, exactly what numbers of plants of each species, as regards age, size, quality, and class (seedlings or transplants) are in the nursery. This annual inventory of the nursery stock will form a basis for drawing up annual plans as regards the disposal of existing stock and the raising of more stock.

6. The following tools (minimum) are required for nursery work —
- Pick axe.
- Spade.
- Ordinary hoe.
- Pronged vine hoe.
- Garden rake.
- Dutch hoe with 6" blade.
- Drilling board.
- Wooden roller.
- String and pegs.
- Watering can with rose.

7. The order in which the various nursery operations should be carried out and the exact time when they should be done are most essential for successful nursery practice. The exact time, for example, of sowing, weeding, watering, shading, transplanting, etc., all require the
careful and personal attention of the Range Officer or the
person in charge of nurseries; delay or neglect in any
of these operations may mean a considerable loss in
nursery stock.

8. The size of a nursery depends on the number, size and kind of the plants (seedlings or transplants) required annually for planting purposes. If the trees to be planted are scattered and the number of plants required in each area is small, it is sufficient to prepare temporary nurseries on the spot in each area under
regeneration. But temporary nurseries, though cheap, are
sometimes unsatisfactory, as they cannot be properly attended
and supervised. Where a large area has to be planted
permanent nurseries on standard lines should be started
and maintained at each working centre from which plants
are to be quickly and cheaply distributed to the planting
areas.

9. The nursery should be centrally situated, as near as is feasible, in the
forest region in which planting is to be done. It should be easily accessible to the Range Officer, and located as far as possible, near a Range Quarter, a range resthouse, a Forest Officer's quarters or a Guard's hut, so that it can be constantly and closely supervised by the staff. It is also important to locate the nursery near a big village so that sufficient labour is available and much time is not
wasted in going to, and returning from work. The nursery should be easy to irrigate (near some well, canal
or river).

10. As regards the actual site, it should be selected on the best available soil and aspect. An open well drained site in good loamy soil with a moderate slope is ideal. Narrow valleys and stiff clay soils should be avoided. No
overhead shade is needed, but side shade from the hot sun is desirable. The best site is an area of forest land recently cleared of trees.

11. The site must of course be favourable for the
growth of particular species which is to be grown, and
if more than one species are to be raised an "average site" should be selected where the soil is neither too light, nor too heavy, too
wet nor too dry, too cold nor too warm, so
that species of different requirements can be successfully
grown.
12. The best possible site should always be selected so that the healthiest stock may be raised. It is a mistaken belief that when planting is to be done on a poor site with inferior soil, the stock should be grown on a similar soil. The stock for planting on all sites should be as well developed and vigorous as possible. It should be grown on the most favourable soil and under the best conditions.

13. Nursery sites should have a gentle slope. Flat areas are not well drained and are liable to frost. Slopes steeper than 5 degrees should be avoided when practicable, as on such slopes terracing is necessary to form seed beds and this is expensive. Considerable losses of nursery plants are sometimes caused by frost, particularly the late spring frosts which occur after the plants have begun to grow. So it is necessary, when choosing a site, to avoid frost hollows. A northern aspect should ordinarily be preferred to a southern, but at high elevations warmer aspects will give better results. Shelter from wind is desirable, but is not essential for most species.

14. In establishing new nurseries, all stones, stumps and roots should first be removed. Bushes and herbaceous weeds should be uprooted and burned. The ground should then be ploughed or plowed to a depth of about 1 foot; except very light soils which need not be worked deeper than 6 inches. This work should be done some six months before the actual sowing of the species. The soil should be left fallow till the actual sowing operations are about to be taken in hand, when all lumps should be thoroughly broken up. Small stones, grass and other vegetation removed and the soil smoothed for laying out the nursery beds. In re-preparing beds in old nurseries it is merely necessary to dig up the beds, remove all small stones, roots, grass and other litter and smooth the soil.

15. In a new nursery, especially when it is located in a recently fallow or an area manuring is generally not necessary. This must, however, be done when it is required, especially in an old nursery which has been impoverished by raising stock year after year without leaving the land fallow. Light soils can be improved by the addition of cow manure and heavy soils by the addition of leaf mould and culture. Vegetable litter, cow dung
and wood ash are the best manures for forest nurseries: they can be easily and cheaply obtained and should be used whenever necessary. If possible, however, it is better to fresh straw manure should not be used; it should be allowed to rot for a year or more in a pit before use. The manure should be spread over the bed 2–4 inches thick and dug into the soil. All bushes, grass and other vegetable litter should be burned over the bed and the ashes mixed with the soil. In all permanent nurseries where new long, vegetable litter and wood ash is not cheaply available such as most of the nurseries in the plains and low hills each part of the nursery should be green manured (by cultivating, cowpeas, Sun-hemp, velvet beans, Egyptian clover or Soybean beans), in rotation. In high hills such as Manali in Kulu green manuring is not much seen because other manures are easily available and due to the rigours of the climate, growth of the green manuring crop is very poor.

16. The shape of a nursery wherever possible should be rectangular or square. Every large nursery should be permanently divided by paths and cross paths into blocks. Whether square or rectangular in shape, the blocks should then be properly laid out into definite rectangular beds with paths in between with a string and pegs. The main paths should be 2 feet wide and the paths between the beds 1½ to 2 feet. The shape and size of beds would differ with the species and the locality. In the hills the standard size of a nursery bed is 6' × 3'. The beds are raised 9” above ground level by throwing the earth from the intervening paths on to the beds. The long side of the beds should be towards the hottest sun, e.g., on southern aspect the long side should be from east to west. This will facilitate shading of the beds if it is necessary.

17. In the plains and the low hills the nurseries are usually irrigated from wells or water channels, hence in the layout considerable attention has to be paid to efficient distribution of water. The nursery is divided into four parts by two central paths 3–4 feet wide intersecting each other in the centre. Each part is divided into a number of rectangular beds separated by 2 feet paths. But it would be better to sow in parallel ridges than in beds. Seedlings will grow with greater rapidity on such
ridges than in beds, and will be more easily transplanted. The ridge should be so high as to ensure its top being above water when beds are irrigated. Raised beds are indicated for species requiring well-drained conditions and for localities with heavy rainfall which is likely to spoil the ridges even with the first shower.

18. The actual seed beds should be well dug up; the soil thoroughly loosen ed and beds prepared just before sowing. The surface of the bed should be absolutely flat and not raised in the centre, otherwise all the seed will be washed off to the sides. The sides of the beds should be consolidated by ramming or with planks or saplings pegged down. The beds should be serially numbered by means of wooden or iron plates.

19. The nursery should be effectively fenced, and gates or turn-stiles should be constructed at suitable points.

20. While collecting seed the range officer should satisfy himself that the seed is derived from the best strain and every effort should be made to collect seed from outstanding trees. In selecting the parents it should be seen that these have adopted to the local climate. Chil seeds shall never be collected from trees of twisted fibre.

21. In case a seed bearing plantation is going to be felled or thinned, it is worthwhile to carry out the felling when the seed is ripe so that cones or fruits can be collected. Collection of seed from standing trees is a slow and dangerous operation. Large fruits such as oak, chestnut, haw, walnut, etc., can be picked up from the ground under groups of well-shaped trees.

22. Most of the seeds should be soaked for 24 to 48 hours before sowing. Prospects baldoriae seed should be extracted from the pods (hand extraction is expensive). The best method is to pass the dried pods through a light "Charki". Mulberry seed should be rubbed with kerosene oil to avoid insect damage. One bottle is enough for one month seed. Bakhai seed should be soaked in thick mixture of cowdung, earth and water for about 10 days before sowing. Nenam seed must be detached before sowing. Cypress nut seed should be filed flat at the "White line"
end of the seed till the kernel just becomes visible, and
the dried seed is soaked in water for 24 hours if the
weather is dry. Seeds with any hard teguments can be
best softened with hot water and dilute sulphuric acid.
Before sowing seed should be detached and stones soaked
for 24 hours prior to sowing. Horace's stone clip at broad
end till the kernel is quite visible and the stones soaked
for 24 hours in cold water give the best results. In case
of Arjen care should be taken that only half the fruit be
buried in the ground.

23. The nursery beds should be sown broadcast or in drills according as the young plants have to be planted
out in the nursery lines before being put out into the
forest or not. The plants which have been pricked out in
nursery lines are called transplants, while those which
have not been transplanted in the nursery are called
seedlings. In broadcast sowing, the seeds should be
scattered as evenly as possible over the entire
surface of the bed, sown rather thick and lightly
covered either with hand or by sprinkling or raking
fine earth over them. Drill sowing is done either lengthwise or across the beds. The drills if
lengthwise should be 5 in number 0.5" apart with .45"
between the outer drills and the edge of the bed, if the
drills run crosswise, they should be 10 in number .75"
apart, with .45" between the outer drills and the edge of
the bed. If a drilling board is used all drills must be
laid out with a string and pegs and sticks cut to the
standard measurements. The seeds in the drills should
be spaced to 1" apart, about 0.5" deep and lightly covered
by scraping earth over them with the hand or garden rake
from both sides of a drill. After sowing the soil of the
bed must be properly consolidated with a light wooden
roller 3 feet wide or with the feet. When the germination
capacity of the seed is not high, deeper sowings in the lines
should be carried out to as to produce the above spacing.
If the seedlings have to remain more than 12 months in
the nursery beds before transplanting in the forest, the
lines should be 3" apart and the seeds should be spaced
3" in the lines. The drills which run parallel to each other
may be laid out by pressing a driling or making board
of a wooden frame 0.5 x 3", on which are nailed battens of
the required shape, width and thickness, this can be readily prepared in every division) into the surface of the seed bed to a depth of 3" to 4". After sowing the seed, the drills should be covered, and florns put over the bed to keep off birds and rodents.

24. The approximate quantity of seed to be sown per bed can be found out by the following formula:

\[ W = \frac{A \times D \times P \times N}{100} \]

Where \( W \) = Weight of seed required in ounces.

\( A \) = Area of bed in square feet.

\( D \) = Number of plants required per square foot.

\( P \) = Plant per cent of the seed.

\( N \) = Number of seed per ounce.

25. The following table gives the months in which seeds of important Punish species are collected; number of seeds per ounce, approximate plant percentage of the seeds; and the time of sowing of each species:

<table>
<thead>
<tr>
<th>Species</th>
<th>Month in which seed is collected</th>
<th>No. of seeds per ounce</th>
<th>Plant percentage</th>
<th>Month in which sown is done</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia nilotica</td>
<td>September-October</td>
<td>450</td>
<td>40</td>
<td>Probably early in December, otherwise in the middle of snow.</td>
</tr>
<tr>
<td>Acacia sebestena</td>
<td>February-Nov.</td>
<td>220</td>
<td>25</td>
<td>Day of June or early in July.</td>
</tr>
<tr>
<td>Acacia catechu</td>
<td>January-March</td>
<td>1100</td>
<td>10</td>
<td>Early.</td>
</tr>
<tr>
<td>Acacia cardenii</td>
<td>July-October</td>
<td>140</td>
<td>30</td>
<td>Early in December.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species</th>
<th>Month in which seed is collected</th>
<th>Number of seeds per pound</th>
<th>Planting percentage</th>
<th>Month in which seed is due to germinate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lycium barbarum</td>
<td>September, October</td>
<td>14</td>
<td>83</td>
<td>Early in December</td>
</tr>
<tr>
<td>Ruta graveolens</td>
<td>January, April</td>
<td>1000</td>
<td>50</td>
<td>Spring</td>
</tr>
<tr>
<td>Anacardium occidentale</td>
<td>December, March</td>
<td>600</td>
<td>40</td>
<td>Spring</td>
</tr>
<tr>
<td>Ricinus communis</td>
<td>May</td>
<td>50</td>
<td>160</td>
<td>As soon as the seed is collected</td>
</tr>
<tr>
<td>Datura stramonium globally distributed</td>
<td>April, May</td>
<td>400</td>
<td>80</td>
<td>Immediately after seed collection</td>
</tr>
<tr>
<td>Cedrus deodara</td>
<td>May, June</td>
<td>10,000</td>
<td>95</td>
<td>As soon as the seed is collected</td>
</tr>
<tr>
<td>Cedrus deodara</td>
<td>September, November</td>
<td>250</td>
<td>60</td>
<td>Preferably early in December otherwise on melting of the snow</td>
</tr>
<tr>
<td>Delonix regia</td>
<td>November, March</td>
<td>2500</td>
<td>50</td>
<td>Early in March</td>
</tr>
<tr>
<td>Eucalyptus nitens</td>
<td>May, June</td>
<td>500</td>
<td>160</td>
<td>As soon as the seed is collected</td>
</tr>
<tr>
<td>Eugenia jambolana</td>
<td>May, August</td>
<td>50</td>
<td>50</td>
<td>Bound week of February in bottom leaf peels</td>
</tr>
<tr>
<td>Oreocnide sphaeroidea</td>
<td>October, December</td>
<td>500</td>
<td>35</td>
<td>As soon as the seed is covered</td>
</tr>
<tr>
<td>Flemingia nobilis</td>
<td>October, November</td>
<td>3500</td>
<td>60</td>
<td>Early spring</td>
</tr>
<tr>
<td>December to February 1</td>
<td></td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Months in which seed is collected</td>
<td>Number of seeds per pound</td>
<td>Plants percentage</td>
<td>Months in which new seed is planted</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------------------</td>
<td>---------------------------</td>
<td>------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Mangifera indica</td>
<td>January-February</td>
<td>100</td>
<td>40</td>
<td>Soon after the seed is harvested</td>
</tr>
<tr>
<td>Metasequoia</td>
<td>January-February</td>
<td>60-80</td>
<td>40</td>
<td>Ditto</td>
</tr>
<tr>
<td>Malus indica</td>
<td>June-August</td>
<td>45</td>
<td>65</td>
<td>Immediately after seed collection</td>
</tr>
<tr>
<td>Morus alba</td>
<td>April-May</td>
<td>12,000</td>
<td>44</td>
<td>Ditto</td>
</tr>
<tr>
<td>Prunus serrulata</td>
<td>October-November</td>
<td>1,000</td>
<td>44</td>
<td>End of June</td>
</tr>
<tr>
<td>Prunus avium</td>
<td>September-November</td>
<td>250</td>
<td>50</td>
<td>Ditto</td>
</tr>
<tr>
<td>Prunus domestica</td>
<td>January-June</td>
<td>250</td>
<td>50</td>
<td>Ditto</td>
</tr>
<tr>
<td>Prunus avium</td>
<td>May-June</td>
<td>440</td>
<td></td>
<td>Immediately after collection of seed</td>
</tr>
<tr>
<td>Gleditsia piloto</td>
<td>December-February</td>
<td>20</td>
<td>56</td>
<td>Early spring in Mexico, The winter or early spring for dried sowings</td>
</tr>
<tr>
<td>Tamarix armeniacana</td>
<td>Ditto</td>
<td>20</td>
<td>34</td>
<td>Ditto</td>
</tr>
<tr>
<td>Tamarix brianza</td>
<td>February</td>
<td>72-138</td>
<td>22</td>
<td>Ditto</td>
</tr>
<tr>
<td>Tamarix corylifolia</td>
<td>March</td>
<td>31 to 102</td>
<td>18</td>
<td>Ditto</td>
</tr>
</tbody>
</table>
30. In view of the uncertainty as regards plant percentages and damage from insects, twice the above quantity should be used in drill sowings and 6 times for broadcast sowings.

27. Chil, Kail, Kilir and Khair don't do well if transplanted and the percentage success is very poor since these species need not be raised in nurseries. Picea cf. richardii and Eucalyptus species should always be raised in bottomless pots. The nursery technique of Picea cf. richardii is given in detail in Mohan's publication "Punjab Forest records Volume 1, No. 9.

28. Chil, kail, and spruce seeds should be soaked for 24-48 hours before sowing.

29. Transplanting in nursery lines is expensive and should be resorted to only when the locality to be re-stocked is poor and the conditions of growth are so unfavourable that seedlings taken direct from the seed beds have little or no chance of success. Seedlings should be picked out while quite young at the back of the values when 6 months old, silver fir when 18 months old and spruce fir when one year old. The seedlings from broadcast sowings should be lifted carefully with a trowel or by opening a trench along the outside of the bed and lifting the seedlings with a spade into the trench. They should be separated by hand, sorted and transplanted in parallel nursery lines 3'X6". Each seedling being placed in a hole with its collar level with the surface and the earth pressed round it or a planting board may be used as described in the text books. The weakest and worst shaped plants should be discarded. A second transplanting, if required, should be done when the watch is 15 years and silver fir 24 years and spruce 2 years old, the plants being spaced 45" apart in line 9" apart.

30. (1) Beds and insect: Immediately after sowing the beds should be covered with thorny branches to prevent birds from damaging the seed and as soon as the germination is complete, the thorns placed on the beds should be removed. To protect seedlings against ravages by cut-worms, the beds should be given a dressing of lime, ashes, arsenic or tobacco water. If these measures are not successful, cut-worms should be collected on moonlight nights or early mornings and destroyed.
(iii) Weeding.—The nursery beds should be kept thoroughly weeded and the soil well-worked up. Congested lines in beds should be thinned out. The object is to produce vigorous healthy plants as early as possible, and therefore no delay in thorough weeding, soil working or thinning out, especially at the beginning of first rains, should be tolerated. One weeding in June and another in August should be done. Soil should not be worked when wet.

(iv) Watering.—Nursery beds should be watered whenever necessary and feasible, especially in the hot dry weather before and after the rains. Irrigation by percolation or by sprinkling from watering cans should be adopted using in the latter case only cans with the finest possible rose. Care should be taken that over-watering is not done, as it is most harmful. It is one of the commonest failings of the nurseries. The beds should be kept fresh but not wet.

(v) Shading.—Nursery beds should be shaded whenever necessary either to protect them against heavy rain immediately after sowing or against the hot sun after germination or prickling out. The shades can also be used for protecting seedlings and transplants against frost. Bamboo sticks must always be shaded against the sun in the hot weather and frost in the cold weather. No shading is required during the rains. Proper shades which do not leak in holes and which can be rolled up when necessary should be used. Thatch shades are not good as they leak and cannot be moved. Screens made of burlap, canvas, or wooden battens designed to give 60 to 60 percent shade are the best. They should be placed over the beds lengthwise sloping towards the sun and raised about 2 feet above ground level on the lower side, so as to give shade but not prevent lateral light and sun. The shades should be removed on cloudy days and in the rains after germination, and they should be entirely dispensed with when the plants are strong enough to stand the sun. When used as a protection against frost, they should be removed during the day time.
length of roots along the outside of the first line of plants, and then to throw the line of seedlings or transplants backward into the trench with a spade. The plants should then be picked out of the trench, separated by hand, sorted and tied in bundles of 50 or 100 and their roots moistened by dipping the bundles in a bucket of clay and water. All inferior plants should be thrown away. Only as many plants should be lifted every morning or evening as can be planted the same day or transported during the night for planting the next day.

22. In case of certain species (Shisham, mulberry) and in unfavourable localities stump (3 inches of shoot and 8 inches of root) planting possesses definite advantages over transplanting of seedlings. Shoot and root development from stumps in these species is more rapid in the first few years. In unfavourable or in areas with uncertain moisture conditions there is greater certainty of successful stocking by planting stumps. The stumps regenerate their root system from near the bottom of the cut tip and so draw on deeper moisture layers of the soil as soon as their roots get developed. Where weed growth is likely to be heavy and more rapid height growth determines the degree of success, stumps are preferable to transplanting. Stumps avoid adverse factors in the top layers of the soil and are more successful where soil is likely to be eroded. Stumps are easier and quicker to handle than seedlings; and stump planting is a fool proof and quick operation.

33. When the seedlings are about a year old (or of the thickness of an average thumb at ground level), many of them will be fit for being made into stumps. To take out the seedlings the beds are flooded. When the soil is wet and soft plants are pulled out by hand. Only such seedlings are taken out as have the requisite size of thumb thickness at ground level; others are kept in situ till these become fit till later in the season or in the following year. The main root of the seedling is pruned to 8" to 12" and the shoot to 2" to 3". Side roots should be clearly cut off with a sharp instrument to produce a clean cut.

34. The bundles of seedlings and stumps (each bundle transport of 100 stumps or so) should be covered with damp moss.
or moist grass and carefully packed in a killa or tied. They should be carried to the planting site without unnecessary delay and planted immediately.

35. If the distance is great, the bundles should be carefully covered with damp moss or moist grass and sewn up in matting before despatch. On arrival at their destination, the plants or stumps should be at once unpacked, laid in a temporary ditch and covered over with moist earth until they are planted out.

36. In the case of exotics or expensive seed of small size, sowing is better done broadcast in pots or shallow boxes rather than in nursery beds; the seedlings being pricked out in nursery beds when large enough to be handled. The treatment regarding soil, watering and shading is the same as for nursery beds.

37. It is essential that proper records of each nursery are maintained in a standard method. The appended forms 1 & 2 are prescribed to be maintained in each nursery.

38. This very valuable book should be in the hands of every Forest Ranger. It contains a mass of information on the cultivation of the common trees of Northern India, weight of seeds, germination per cent, etc., etc.
FORM NO. 1

1. Name of nursery.
2. Its location.
4. Area in acres.
5. Manner in which fenced.
6. Year in which started.
7. Initial cost on clearance and lay-out, etc.
9. Rent, if any.

10. Map of the nursery showing lay-out and plot numbers, etc.
PLANT STATEMENT (FOR EACH YEAR)
(To be prepared during June and December)

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of beds</th>
<th>Age</th>
<th>Total number of plants</th>
<th>Number of plants planted in Current year</th>
<th>Unused</th>
<th>Available</th>
<th>Number of plants planted in Next year</th>
<th>Used locally</th>
<th>Sent to other Department</th>
<th>Given to public</th>
<th>Total</th>
<th>Remarks</th>
</tr>
</thead>
</table>

---
<table>
<thead>
<tr>
<th>Month</th>
<th>Tools</th>
<th>Feed</th>
<th>Establishment</th>
<th>Feeding</th>
<th>Fertilizer</th>
<th>Other</th>
<th>Sowing and planting</th>
<th>Irrigation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Feb.</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
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<td>18</td>
</tr>
<tr>
<td>March</td>
<td>19</td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
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<td>27</td>
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<tr>
<td>April</td>
<td>28</td>
<td>29</td>
<td>30</td>
<td>31</td>
<td>32</td>
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<tr>
<td>May</td>
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<td>38</td>
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<td>41</td>
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<td>43</td>
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</tr>
<tr>
<td>June</td>
<td>46</td>
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<td>48</td>
<td>49</td>
<td>50</td>
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<td>52</td>
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</tr>
<tr>
<td>July</td>
<td>55</td>
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<td>57</td>
<td>58</td>
<td>59</td>
<td>60</td>
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<td>63</td>
</tr>
<tr>
<td>Aug</td>
<td>64</td>
<td>65</td>
<td>66</td>
<td>67</td>
<td>68</td>
<td>69</td>
<td>70</td>
<td>71</td>
<td>72</td>
</tr>
<tr>
<td>Sept.</td>
<td>73</td>
<td>74</td>
<td>75</td>
<td>76</td>
<td>77</td>
<td>78</td>
<td>79</td>
<td>80</td>
<td>81</td>
</tr>
<tr>
<td>Oct.</td>
<td>82</td>
<td>83</td>
<td>84</td>
<td>85</td>
<td>86</td>
<td>87</td>
<td>88</td>
<td>89</td>
<td>90</td>
</tr>
<tr>
<td>Nov.</td>
<td>91</td>
<td>92</td>
<td>93</td>
<td>94</td>
<td>95</td>
<td>96</td>
<td>97</td>
<td>98</td>
<td>99</td>
</tr>
<tr>
<td>Dec.</td>
<td>100</td>
<td>101</td>
<td>102</td>
<td>103</td>
<td>104</td>
<td>105</td>
<td>106</td>
<td>107</td>
<td>108</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TECHNICAL ORDER NO. 4

ARTIFICIAL REPRODUCTION

Natural regeneration, though generally superior to artificial regeneration, cannot be relied upon for the complete and rapid regeneration of an area. It must be supplemented by sowing and planting, either to fill up fallow places or to restock blanks. Artificial reproduction is, moreover, required to restock burned areas, clear-felled areas, abandoned cultivation lands, and areas under active erosion to introduce more valuable species in areas otherwise occupied by species of lesser value, such as deodor in pure kail and spruce forests or to increase its proportion in mixed deodor and kail or deodor and spruce, or silver fir forests; to convert oak and other inferior broad-leaved and scrub forests into mixed deodor and kail crops; and lastly to create new plantations and road-side avenues of valuable species such as shisham, mulberry, bakhain, neem, etc.

2. Artificial reproduction is at present used on a large scale in the hill forests of the Punjab and in areas closed under Punjab Land Preservation Act, Section 38 of Indian Forest Act, and strips along the Canals, Roads and Railway, and with intensive forest management it is likely to increase. The present methods of sowing and planting differ in different divisions: the technique of artificial reproduction in all aspects is therefore discussed here and the procedure to be followed in future is hereby standardized.

3. The success of artificial reproduction largely depends upon the proper organization of labour and work. No more should be attempted than can be successfully completed. The closest attention should be given to every detail of the work and this should be constantly supervised. Range Officers, Forests and Forest Guards should understand the technique and practice of artificial regeneration, and should be able to show the labourers exactly how to sow and how to plant, and the students of the Forest School should be fully instructed in these methods.

4. The easiest areas should be regenerated first so that with success on easy ground the subordinate staff may
be encouraged to succeed with artificial work on difficult areas.

5. It need hardly be emphasized that, the species selected for cultivation should be entirely suited to the local soil and climate. It should be one of the valuable species of the locality provided it is silviculturally suited to the area to be artificially stocked. The choice is easy in the case of supplementing natural regeneration. Deodar should by all means be introduced in pure kail and fir forests where conditions are favourable and its proportion increased in mixed deodar and kail or deodar and fir forests. But when doing this, in low and medium level kail forests, deodar should always be put on the cooler aspects, and in fir forests only on the well drained warmer aspects. On the outer range of the Himalaya, where deodar is not indigenous, i.e., Kangra, particular attention must be paid to site value. Deodar should not be planted on hot, dry, bare hill sides, nor should the whole-sale conversion of fir forest into deodar be attempted; such attempts in the past have invariably resulted in failure and waste of money. Bare, dry, hot slopes are more suited to kail and Cupressus torulosa, especially on limestone rocks. Damp, low-lying and flat sites, especially in the middle and high level Zones, are entirely unsuited to conifers, and such sites should be restocked artificially with broad-leaved trees, e.g., walnut, maple and horse-chestnut, or left alone.

6. To obtain success in artificial regeneration perfectly ripe and sound seed of good quality should be used. It should be collected from dominant, well shaped, vigorous, straight-fibred trees, which have reached middle age; seed collected from trees too young or too old and from suppressed and unsound trees is generally bad. Seed from twisted trees should on no account be used, and in the case of Chil special care should be taken that cones are not collected from areas where twist is common; this defect is inherited by the offspring of twisted parents. Twist in common in the Chil Forests of Una range; this seed should never be used. In selecting the parents it should be seen that these are adapted to local climate; for example, kail and spruce seed required for artificial regeneration at high levels should not be collected from medium or low levels and vice versa.
as sowings of lent at 9,000 feet in Kulu with seed collected from trees growing at medium or low levels have so far failed.

7. The quality, germination percentage and vitality of the seed are markedly better in a good seed year than in a bad seed year, and so in a good seed year as much seed should be collected as can be utilized for direct sowing and nursery work, making special arrangements well beforehand for extensive sowings and nursery work.

8. In case of conifers cones must be collected in time otherwise the seed may be shed before collection started. Deodar seed ripens in October-November, Kail in October, spruce and silver fir in the end of September-October and chil in December. Chil seed should be collected from felled trees any time after the beginning of December provided no cones are chosen under 4" long. The previous practice of collecting chil cones in April-May from standing trees at a considerable cost is unnecessary when the cones can be collected from trees felled in exploitation. The cones should be placed in the hot sun to open and the seed dried and cleaned of cone scales, wings, unsound seed and other foreign matter.

9. Any division requiring seed in excess of what it can produce itself should send in an indent to the Silvicultural Research Division which acts as a clearing house for seeds. To enable the Divisional Forest Officer, Silvicultural Research Division, to make satisfactory arrangements for seed supply, he should be informed by Divisional Forest Officers as soon as possible, where the seed crop has failed and where it is likely to be abundant together with approximate quantities required or available for use elsewhere.

10. Only clean, dry seed should be used and despatched.

11. The seeds of broad leaved species can generally be stored without any loss of vitality for over a year. Seed should be stored in tin canisters or tin lined boxes and care should be taken that the seed is dry before being
placed in the time of boxy. Large quantities can be kept in bags, but these must be stored in a dry airy place, where the seeds will not become mildewed. Coniferous seeds cannot, however, be stored for long periods; *Picea* and *Abies* are stored before snowfall, and spruce and *Pinus* seeds are stored till June. To store beyond these dates is waste of seed and money.

12. Seeds of various species should be soaked in water for 24 to 48 hours before sowing. *Picea* and *Pinus* seed should be extracted from the pods (hard extraction is expensive, the best method is to pass the dried pods through a light chopper); mulberry seed should be rubbed with kerosene oil to avoid insect damage (one bottle is enough for one round seed); bakin seed should be soaked in a mixture of cowdung, earth and water for about 10 days before sowing; *Sequoiadendron* seed must be depulped before sowing; comfruit seed should be filed flat at the "white line" end of the seed till the kernel just becomes visible, and the filed seed is soaked in water for 24 hours if the weather is dry. Seeds with any hard teguments can be best softened with hot water and dilute sulphuric acid. Before fruits should be depulped and stones soaked for 48 hours prior to sowings. *Harrar* stones clipped at broad end till the kernel is quite visible and the stones soaked for 24 hours in cold water give the best results. In case of *Armeniaca* care should be taken that only half the fruit is buried in the ground.

13. An area may be regenerated artificially either by direct sowing or by planting. The choice between sowing and planting depends upon the site to be stocked, the species used and the quantity of seed available. On difficult areas, such as poor exposed soils, hot dry localities, sites overgrown with thick grass, heavy weeds and shrubs, steep slopes, land slips, etc., planting is much more certain and the whole less expensive than direct sowing. Planting is also more likely to succeed where failures in both natural and artificial regeneration have to be replaced.

14. In high hills broad leaved species such as walnuts, *Corylus*, *Castanea*, *Salix*, willows, etc., should be planted because development period is limited due to long cold spell.
and by planting the plants have a definite initial advantage. Cèd and kail are generally sown and not planted as direct sowings of the two pines are more certain and their transplanting has met with indifferent success. Deodar is both sown and planted. Spruce and silver fir can be both planted and sown, but planting of fir should be preferred to sowing, as in the first place the paucity and cost of seed does not allow of sowing on any large scale and the growth of the young seedling is very slow; secondly, spruce and silver fir areas are generally very weedy and direct sowings have very little chance of success. Acacia arabica and Acacia catechu are sown as transplanting of Acacia with naked roots has met with poor success. *Shishum*, mulberry, *Samul*, etc., give best results by planting.

15. There are large areas of half forest on ground suited to deodar. In many localities the kail is infested with *P. mellite* and conversion to deodar is prescribed. In working plans, the half forest is gone over in shelterwood fellings, and after conversion is complete, slash is collected into small heaps and bushes are cut and burnt. Deodar seed is sown either broadcast, or in patches according to the quantity available. These patches form temporary nursery beds from which seedlings are transplanted in subsequent years. The distance between the deodar transplants should be from 8 to 12 feet as it is sufficient to obtain a small proportion of deodar in the future crop.

The kail seeds profitably and an ideal mixture of deodar and kail is obtained.

16. Similarly valuable broad-leaved species such as walnut, ash, bird cherry, horse chestnut should be introduced in areas of fir and spruce which inspite of seedling fellings are not regenerating themselves and are being invaded by weedy weeds. Transplanting at a distance of 10' x 10' would give ideal results.

In low hills *khowr* is a valuable species and should be introduced by patch sowing 12' x 12' (size of patch being 2' x 2') in areas occupied by poor scrub and blankets.

17. Forest fires have done much damage in the past and burns sometimes extend to over a hundred acres in burnt areas.
18. The bushes and dead trees are cut out and the area is isolated to prevent fire spreading to neighboring forests and the whole is then set on fire when dry. No attempt is made to burn the trunks of the trees completely.

19. Seed is sown broadcast and transplants are put out in subsequent years. It is essential to tackle the areas as soon as possible after the forest fire, as bushes and weeds grow space: consequently when sufficient seed is not available, transplants from permanent nurseries must be put out at once.

20. Seed beds on cool aspects must be weeded regularly, but on hot exposed aspects it is advisable not to weed the young deodar seedlings during the first year as they suffer severely from drought.

21. In artificial regeneration mixed crops are to be preferred. The mixture should not be by single trees or by lines but, preferably, by groups of suitable size. Broadcast and patch sowings of liquid and deodar should be carried out in groups of 150 x 150. The sites unsuitable for deodar and infertile being occupied by groups of sparsce, silver fir and valuable broad-leaved trees like ash, walnut, etc. This method was successfully tried in Nagni (Kulu) before the area under regeneration was destroyed by fire in 1921. It is even easier to raise mixed crops in groups when the area is being stocked by planting.

22. Direct sowings.

<table>
<thead>
<tr>
<th>Species</th>
<th>Time of sowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternifolia</td>
<td>February before the melting of snow.</td>
</tr>
<tr>
<td>Acacia cathartea</td>
<td>April or May.</td>
</tr>
<tr>
<td>Acacia catechus</td>
<td>April.</td>
</tr>
<tr>
<td>Alstonia falco</td>
<td>April.</td>
</tr>
<tr>
<td>Alstonia pseudop</td>
<td>April.</td>
</tr>
<tr>
<td>Alstonia stipule</td>
<td>April.</td>
</tr>
</tbody>
</table>

Time of sowing—The following table gives the time of sowing for important Punjab species:
<table>
<thead>
<tr>
<th>Species</th>
<th>Time of sowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banaba inophylla</td>
<td>Immediately after seed collection.</td>
</tr>
<tr>
<td>Banisteria colorata</td>
<td>Ditto</td>
</tr>
<tr>
<td>Balsam Echinodorus</td>
<td>Ditto</td>
</tr>
<tr>
<td>Cuscuta reflexa</td>
<td>Prickly early in December otherwise on melting of snow.</td>
</tr>
<tr>
<td>Ficus carica</td>
<td>Early in March.</td>
</tr>
<tr>
<td>Helicteres callistoma</td>
<td>As soon as the weed is collected.</td>
</tr>
<tr>
<td>Haplopappus hirsutus</td>
<td>Second week of February in bottomless pots.</td>
</tr>
<tr>
<td>Lagerstroemia floribunda</td>
<td>As soon as the weed is collected.</td>
</tr>
<tr>
<td>Genista angustifolia</td>
<td>Hardly so, anyway.</td>
</tr>
<tr>
<td>Jaglanth, regia</td>
<td>December to February.</td>
</tr>
<tr>
<td>Mangifera indica</td>
<td>As soon as the weed is collected.</td>
</tr>
<tr>
<td>Mabila inornata</td>
<td>Ditto</td>
</tr>
<tr>
<td>Mabila indica</td>
<td>Ditto</td>
</tr>
<tr>
<td>Maras alba</td>
<td>Ditto</td>
</tr>
<tr>
<td>Ficus sycomorus</td>
<td>End of June (about the break of summer).</td>
</tr>
<tr>
<td>Phascolandra robusta</td>
<td>Ditto</td>
</tr>
<tr>
<td>Phascolandra robusta</td>
<td>Ditto</td>
</tr>
<tr>
<td>Phascolandra robusta</td>
<td>Immediately after collection of seed.</td>
</tr>
<tr>
<td>Phascolandra robusta</td>
<td>Early in spring or winter.</td>
</tr>
<tr>
<td>Pueraria speciosa</td>
<td>Ditto</td>
</tr>
<tr>
<td>Ternarius leucophylla</td>
<td>Ditto</td>
</tr>
<tr>
<td>Tenuvalia helvetica</td>
<td>Ditto</td>
</tr>
<tr>
<td>Tenuvalia helvetica</td>
<td>Ditto</td>
</tr>
</tbody>
</table>

(b) Methods of direct sowing.—Direct sowing can be carried out by the following methods:—

(i) broadcast over the whole area,
(ii) in lines,
(iii) in patches.
(i) Broadcast sowings over the whole area.—Broadcast sowings may be carried out on clear-felled areas, burnt areas or exceptionally weedy areas. All dry standing trees, bushes and other rank growth should be cut, collected and burnt completely along with the fallen refuse and thick raw humus, in accordance with Technical Order No. 8. A really hot fire should be arranged as far as possible. This operation should be completed well before the sowing season. The seed should then be sown broadcast over the whole area and lightly covered either by ramming or heeling. Broadcast sowing can also be successfully employed in forest where the soil is in good condition as indicated by plant indicators such as the strawberry and Indigofera for deodar and Berberis and Myristica for Chil and when seed is abundant in a good seed year. In the case of deodar, 10 seeds of seed to the acre is the maximum for this sort of sowing. For Chil about the same quantity, for kail and silver fir about 4 and for Spruce about 6 the amount will be required. The quantity of seed required would depend upon size and plant percentage of the seed.

(ii) Sowing in lines.—Terraced lines in hills and straight lines in the plains 1′ wide on average sites and 1′2′ wide in areas with excessive weeds and bushes should be made along the contours, every 10′ apart. The soil of the terraces should be well dug up and prepared and seed sown either broadcast or in one drill in the central.

(iii) Sowing in patches.—Patches 5′×5′ should be prepared 10′ apart from edge to edge except in areas of heavy undergrowth when the patches will be 2′×2′. Shrubs and herbaceous weeds should be uprooted and the soil dug 2′—12′ deep. The slope of the surface of the patches must conform with that of the hillside; otherwise water collects in the patches when snow melts and during the monsoon and the plants die. Too fine a tilth is not advisable as the soil erodes after rain. It is sufficient if the clods are broken to the size of a man's fist as in koreli wheat cultivation. The rubbish when dry should be burnt over the patches. The seed should be sown broadcast on the patches and lightly covered.
When transplanting from patches is to be done, the patches should be made 15' to 20', apart from edge to edge in the line, the surplus plants being transplanted when of suitable size between the patches.

Small patches 1-1/2 foot square are no good, especially in weedy areas, and should not be made. In heavy clay soils and areas with large shrubs, patches should be prepared in advance and the soil somewhat broken up and exposed for some time for weathering. The final preparation of the patches can be made at the time of sowing.

After the completion of exploitation in felled areas, falling residue and raw humus should be raked up into small heaps and burnt in accordance with Technical Order No. 6. The seed should be sown broadcast on these burnt patches and lightly covered by stirring up the ashes.

23. (i) Planting stock, its size and age—The planting stock will usually be nursery raised, seedlings, transplants, pot plants, and stumps. Nursery work will be carried out in accordance with Technical Order No. 3.

Surplus seedlings from direct sowings may also be used for planting. Planting wild stock has generally proved unsatisfactory and should be avoided.

As a general rule, seedlings, i.e., plants which have not been pricked out in nursery lines, should be planted on average sites and transplants, i.e., plants pricked out in nursery lines, on difficult sites.

The size and age of the stock for planting varies with the site and the species. No plant with a shoot less than 9 inches in length should ordinarily be used. Exposed areas and sites subject to drought, or excessive weed growth must be planted up with large plants. Ordinarily desirable seedlings should be planted out when 14 years old.
but in difficult weedy areas, 24 years old transplants picked out once or even twice in nursery lines should be used. Trees for should not be planted under 24 years old and spaced under 2 years old, and it may be necessary to keep these plants longer in the nursery. If tall trees to be planted, 3 year old kaffir seedlings should be used. Chilch
not be planted with naked roots. In South Africa it is invariably planted in loam. Stumps should be about 10" in length with 2'-3' of shoot and the remaining 4'-10' of root.

(ii) The time of planting.—Planting of konifers should always begin immediately after the first heavy winter rain in July and finished by the first week of August at the latest as later plantings are generally unsuccessful. Cloudy and rainy days should be selected for this work and bright sunny days avoided. On hot southern slopes to ensure success, transplants should be put out on upper side of bushes. Planting of oak, walnut, elm, elder, hill mulberry and bread leafed species in the high hills should be done in December/January before snowfall when the plants are one year old and are leafless.

In the plains, however, planting should begin immediately after first rain and should be completed by the end of July at the latest. Whenever irrigation is possible planting can be done both in the monsoon and in early spring—the latter gives more satisfactory results.

(iii) The spacing and the preparation of the planting area.—The standard planting distances are:

(i) 6' × 8' in square planting, and

(ii) 12' × 8' in line planting.

Square planting will be adopted on average sites and line planting in areas of excessive weeds and bushes.

In square planting, planting sites will be marked every 6' apart where weeds and bushes will be cut about 2' × 2' and holes prepared for actual planting. In line planting, about 2' wide contour lines or diagonal lines at right angles to the direction of the hottest sun will be cut through the undergrowth every 12' apart, and in these
lines, the planting sites will be marked and holes prepared every 18'.

In felled over areas, the felling debris should be burnt before planting. In light soils, planting holes should be made just before the plants are put out, or if there are no labour difficulties, simultaneously with the planting. In the case of heavy clay soils and weedy areas, the holes should be prepared early in the summer preceding the rains in which planting is to be done and the earth left in unbroken clods. This allows the soil to be well weathered. For winter planting the holes should be prepared immediately after the rains.

(iv) Methods of planting.—The following theme standard methods of planting will be used:—

(1) Planting of entire plants with naked roots.
(2) Stump planting, and
(3) Pot planting, and planting entire plants with balls of earth.

(1) Planting with naked roots.—The actual method of planting is well known to every trained forester. It is, however, essential to emphasize that in planting: (i) the roots should not be crowded together or doubled up (see Diagrams 4 and 5 how to do and how not to do), (ii) the collar should neither be below the soil level nor above it—it should be in the same position with reference to the surface soil after it has been planted as it was in the nursery, (iii) the plants should never be put out in pits below the surface level of the soil where water will stand.

Correct

Diagram 4
Diagram 5

It must be remembered that after planting the earth sinks, consequently the surface of the soil after planting, should be above that of the ground in the neighbourhood. (iv) the earth must be firmly pressed round the roots and stumped down round the collar; (v) thick humus should be entirely removed from the actual planting sites before planting holes are made, and it should be seen that only good mineral soil is placed in contact with the roots and not the litter and organic matter of the upper soil layer and (vi) in weedy areas transplants should be staked.

(2) Stump planting.—Planting of stumps is a very simple operation. The planting site is well watered to facilitate planting when the soil is well saturated, stumps are pushed in by hand so that the root part of the stump is completely driven into the soil (i.e., about 3” to 10”). Stump part (i.e., about 2” to 3”) is left above ground. Stumps are not pushed in exactly vertical down, but rather slantingly in irrigated areas so that the uppermost part is slightly away from the water channel. If the ground is hard and stumps cannot be pushed by hand a wooden peg is driven in to prepare a planting hole. After planting the hole is closed and the earth around it is pressed home with hand.

(3) Pot planting and planting entire plants with balls of earth.—Where the ordinary methods of naked root planting fail and the area must be stocked, this kind
of planting should be adopted. This is undoubtedly the best method of raising certain species, such as Phascolaristea and Eucalyptus spp., and for other species under adverse conditions both of moisture and soil. Bottomless pots 6" to 8" deep 4" wide at top and 31" at the bottom should be filled with light clay or sandy loam (or better still local soil mixed with leaf mould or farm yard manure) and kept in beds 6" deep which are prepared to receive them. Two or three pretreated seeds are sown in each pot. The pots are watered by flooding the beds which enables the water to rise by percolation. When the seedlings are a few weeks old the spare seedlings are taken out of pots and planted in failed pots. Tending in the nursery consists of frequent watering and occasional shifting of the pots to prevent the tap root getting in the ground. This also encourages development of bushy roots. The roots may be pruned if they get in the ground. The plants are fit for planting when the shoots have attained finger thickness. Planting should be done early in rains so that plants get the full benefit of the rainy season. For actual planting, requisite holes should be dug. Plants with balls of earth should be withdrawn from pots and inserted into the holes. Soil is then well pressed to avoid sinking after heavy rains.

24. To guarantee success in artificial regeneration, tending both sowing and planting, it is absolutely essential that the plants should be properly weeded, and cleanings and thinnings, carried out as and when required.

(1) Weeding.—Thorough weeding should be carried out in both sowings and plantings. Where weeds are excessive on cool slopes and moist areas, weeding should begin on 1st June and should be repeated in August. In places where undergrowth is not aggressive, one weeding early in the rains is sufficient. Chil seedlings are not harmed by grass, especially in the lower limits and are best left unweeded except in cases of exceptional herbaceous weed growth in burnt areas. Tall weeds like Simrothi and balsam in deccan; kall, spruce and silver fir areas must be cut back in the rains from the upper side of the plants to a distance equal to about their height, so that they may not be flattened over the plants by snow; if this happens the plants will be ruined.
Wedding will generally be required for 3 to 4 years. It is most essential that proper weddings should be carried out thoroughly during the first year.

11. Clippings.—At the age of 11 years surplus plants should be removed from dense sowings and planted where required or thrown away, but with proper attention to the quantities of seeds sown, this should hardly be necessary. Clippings should be carried out so that the plants are spaced approximately 4' x 4' when 6" high.

12. Thinnings.—When the average diameter of the sapling crop is about 4", an early thinning should be carried out with a 4" stick, so that the remaining saplings are spaced 6" x 6". Another early thinning should be carried out when the average crop diameter is 6" leaving the saplings about 8" apart. Subsequently the crop should be thinned in accordance with Technical Order No. 1.

(a) @ fire traces and paths.—Young plantations must be isolated by fire traces and opened up by paths.

(b) By clippings and thinnings.—They must be cleaned and thinned at the earliest possible opportunity, and the cut seedlings and saplings removed as thinned plantations survive a fire whereas thickly stocked plantations suffer severely or are entirely destroyed by fire.

(c) By grazing.—Weeds and grass choke young plantations. As soon as the plants are safe from trampling by grazing livestock, villagers’ cattle must be encouraged. Villagers should be allowed to cut bushes and grass once the seedlings are fully established.

Fences should be removed and the area thrown open to the exercise of recorded rights as soon as is practicable after the plants have reached the young sapling stage and dormant from damage by cattle as a plantation unnecessarily fenced is a source of continued irritation to a rights holder and is direct encouragement to incendiaries.
TECHNICAL ORDER NO. 5

CLOSURES

There appears to be a complete misunderstanding in some quarters as to the meaning and intention in constituting reserved forests free of rights and in imposing closures (other than punitive closures) in protected and other forests. The time has come when further misunderstanding and misinterpretation in this matter must be placed to the discredit of all responsible forest officers concerned.

2. It must be taken as a fundamental principle of forest policy that the reasonable requirements of local inhabitants are, so far as the forests concerned can, satisfy them without imperilling their permanancy, to be met in full before any forest produce is exported from the tract. This applies equally to right-holders and non-right-holders, though the former must of necessity be given first consideration when the quantity of forest produce available is insufficient to meet more than right-holders requirements. It is not the intention that forest produce should be given to non-right-holders free or at concessional rate; it is correct to charge such persons at the local market rates prevailing from time to time, or at rates slightly (say 25 per cent.) higher than those charged to right-holders, whichever is less.

3. There are many parts of the Punjab where the village forest lands, (e.g. III class Protected Forests in the Kulu Civil Division and undermarked protected forests in Kangra proper) are unable to meet the full legitimate demand of the local population for timber and fuel, but where quite extensive resources exist at reasonable distances from the source of demand in the Reserved and Demarcated Protected Forests under the control of the Forest Department. It is far preferable to safeguard the continued existence of the village forests, in such cases by liberal policy of grants to meet the real and reasonable domestic requirement of the people from other Government forest lands than to permit the complete and rapid
exhaustion of the resources of the village forests by adopting the attitude that no timber or firewood is available from reserved and demarcated forests except to right-holders.

4. In particular it is necessary to emphasize most strongly the principle that closure (whether permanent as in the case of Reserved Forests free of all rights or temporary as in the case of areas in Protected Forests closed for regeneration purposes) does not mean that neither man nor beast may under any circumstances set foot in a closed area or receive any sort of forest produce therefrom. A punitive closure is, of course, on a different footing as its name denotes and it is perfectly legitimate to do everything possible to enforce the lesson that forest offences, inviting punitive closure, lead to real inconvenience and discomfort to the guilty. But, in the case of closures imposed for silvicultural reasons, the policy of all forest officers must be to permit anything that is not harmful to the closed area and to use the closure as his servant and not as his master. "When an area is legally closed to the exercise of rights, it means that no person can demand to do any act or to receive any forest produce therefrom; but it must emphatically be noted that he cannot be permitted to do specific Acts or to receive specific forest produce in a closed area when such act or removal is unimportant to the forests and even, as will be the cases in many instances, beneficial to the objects of forest management. It must, therefore, be an axiom of forest management in all forest divisions that restrictions in reserved forests and in areas closed for other than punitive reasons shall be as few as is compatible with the objects of forest management from time to time. It may be desirable to enforce strict and complete closure for part of the period of closure, but all concerned must be ready to relax restrictions and to grant concessions in closed areas as soon as that is not disadvantageous to the interests of the forest and whenever there is a legitimate and reasonable demand for such concessions at the same time the forest officer will always be careful to impose such control over the exercise of such concessions as he knows to be necessary in the circumstances of each case.

But nothing in this order shall be taken as permitting the introduction of buffaloes, goats and sheep into areas
not burdened with those animals as of right. It is most undesirable to encourage any increase of these animals in forest tracts.

5. While the Conservator will often be able to judge whether the policy laid down in this order is being acted upon in the course of his inspections, it is not possible for him to inspect and enquire into the position prevailing from time to time in every closed area. Divisional Forest Officers will, therefore, appeal to the note up the progress of Working Plans prescriptions, which accompanies the annual Control Forms (or in cases where Control Forms are not submitted will submit separately in March each year) a "Report on Closures" in the following form:

<table>
<thead>
<tr>
<th>Division for the year</th>
<th>Report of Closures in the Division for the year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date closure was begun</td>
<td>1</td>
</tr>
<tr>
<td>Date closure was closed</td>
<td>2</td>
</tr>
<tr>
<td>Area category dealt.</td>
<td>3</td>
</tr>
<tr>
<td>Area no. to be treated</td>
<td>4</td>
</tr>
<tr>
<td>Total volume in cubic feet</td>
<td>5</td>
</tr>
<tr>
<td>Number of logs treated</td>
<td>6</td>
</tr>
<tr>
<td>Nature of operation</td>
<td>7</td>
</tr>
</tbody>
</table>

"After entries regarding "closures" will be entered in R. Fa in which comments have been given, their nature and justification thereof being given in column 7 and are affected in column 4.

The form is self-explanatory and it is only necessary to say that the explanations given in columns 6 and 7 must be clear but concise and not mere generalities. Each closed area will be dealt with separately. It will not be sufficient to make a general remark against
all closed areas such as in column 5 "No concession granted" or in column 7 "Grass cutting allowed"—a clear description of the concession and the control imposed must be given as well as a reason for granting or not granting concessions.

6. Each statement will bear at its foot the following certificate—

    Certified that the
    (Name) has inspected personally the Range Officer
    by the areas in the above statement marked—and satisfied himself that no unnecessary restrictions are imposed in any of the areas except in—(name of closed areas)—about which definite instructions have been issued by the
    Divisional Forest Officer.

    (Sd.) Divisional Forest Officer

Dated: Division

7. These instructions are to be brought to the notice of all Range Officers, who are responsible to see that the policy prescribed is not nullified by the action of any of their subordinates and Forest Guards.
TECHNICAL ORDER NO. 6

The Burning of Slash

The proper sanitation of the forest is just as important as that of the town. Diseases of fungi and attacks of insects are spread by decaying wood. A little of slash adds enormously to the fire hazard and by covering the ground prevents the seed from reaching the soil. The only real remedy against epidemics of insects is cleanliness in management and proper attention to silvicultural operations, whereby the trees are kept in vigorous growing condition. The burning of slash was introduced in the State sometimes in the beginning of twentieth century when natural regeneration under the Uniform method first began to receive attention and this work has now become a matter of routine in practically every division. In the past wherever a mass of rotting wood was left lying on the ground in regeneration areas the result usually was that such areas were destroyed by fire. It is a standing order throughout the Punjab (India) that regeneration areas are to be kept clean and all slash of the seedling felling collected and burnt if no other use can be made of the debris. Sometimes this can be sold for firewood. Very often neighbouring villagers are glad to remove it in which case they should be given a reasonable time to collect what they want before departmental burning is commenced. Turner in his monograph "Slash in Chir Pine"—Indian Forest Records, Volume XII, Part VII, deals exhaustively with the whole subject and officers should make themselves acquainted with this publication. In Chapter II he gives details of the treatment of slash of various kinds found in areas under regeneration and the cost of the same and in Chapter V he deals with the technique of burning. The principles underlying the collection and disposal of slash may be summarised as follows—

(1) Start collection from the top of the compartment and work downhill.

(2) Lap branches, roll logs away from seed bearers and stack large slash by hand in open places in moderate heaps of about 50 man’s each.
(3) Make chips and humour downhill on to the heaps of slash.

(4) Burn the heaps downhill.

2. The smoke does not interfere with the men working below and there is less risk of fire. Burn the heaps in rotation to reduce the heat. Women and boys can be employed on taking up the smaller chips. One Forest Guard can hardly control more than 6 labourers and the same man should be employed year after year. A great saving in cost can be effected by attention to the details of how the work is done. For instance it is easier to throw branches downhill than to carry them uphill. It has been found that in the case of chir pine, logs are the most dangerous form of slash and these must be disposed of. For piling the most economical unit is a gang of 6 men. These should be armed with 3 levers 3 feet long and 3 axes. The logs should be levered downhill away from steel-bearing and regeneration to the nearest open place where they can be burnt in small heaps. Piling gangs have nothing to do with firing.

3. Provided the logs are dry, they can be completely burnt without splitting or cutting by covering them with branches and smaller felling refuse. The work of their complete destruction can, if necessary, be completed in two operations; first fire the pile green once, this will render it much less inflammable and in the following autumn burn again when the logs will be completely consumed.

4. The proper time for the collection and burning of slash in chir pine forests is the winter. In the higher hills collection can go on from the melting of the snow and burning is best done in October and November. The risk of damage then is very much less and a good season is available for immediate sawing. Burning in June should generally be avoided; there have been accidents due to burning slash at this time. However in very wet forests it may be necessary to burn in June, in which case special precautions will be taken. Under all circumstances the strictest attention must be paid to the preservation of the mother trees. Chir will stand a good deal
of heat, deciduous, has still less and silver fir will not stand any at all. The subordinate in charge of the work is responsible for the safety of the mother trees and the forest. In chir forests after burning the heaps of slash may be run downwind over the whole compartment under the same orders and procedure as in the departmental burning of chir forest. This will finally clean up the area ready for natural regeneration. Steps will of course be taken to see that chir advance growth or pole crops retained as part of the future crops are not damaged in any way by this operation. As mentioned above silver fir is very susceptible to fire hazard and there is a serious risk of the trees being scorched unless the greatest care is exercised in debris burning.

3. Considerable attention has lately been paid to the humus layer of the forest floor and its effect on success in natural regeneration. There is hardly any doubt that the failure of regeneration in the high lying forests, especially in the case of spruce and silver fir, is due to the large accumulation of undecomposed litter. In all operations connected with slash disposal therefore an effort should be made to get rid of as much of this litter as possible by raking it up with the smaller chips and burning it on the heaps of slash. It is recognized that once regeneration has been obtained the slash from the secondary fellings cannot be burnt. All the same it should receive attention and every effort made to get rid of it. In some cases it has been piled on the stumps of felled trees or thrown into gulches. Owing to great differences in the amount of slash obtained in secondary fellings and the varying nature of the existing reproduction and local conditions each compartment must be treated on its merits.

It has already been ordered.—Technical Order No. 1 that slash from unsalable fellings is not to be left lying about on the forest floor. In most cases less harm is done by leaving trees standing than by felling them and littering the forest with refuse which not only encourages insects but constitutes a continual menace from fire. Steps should be taken to make it a condition of sales of trees locally or to right holders or of grants to free grantees in these people collect their refuse into heaps or remove it from the forest. In road work a mass of inflammable
Rubbish is often thrown immediately below the road which is not only most unsightly but constitutes a menace from fire. In short, Divisional Forest Officers, Forest Rangers, and all ranks of the staff will conduct all their operations with a view to cleanliness and the proper sanitation and protection of the forest estate from fire.
TECHNICAL ORDER NO. 7

FOREST MAPS

Part I

1. To a degree varying with the intensity of forest management applicable to any particular part of the forest estate, methods of management, silvicultural treatment and control of technical forest operations are materially influenced by the maintenance of special forest maps. In the Punjab under present circumstances or under any circumstances which are likely to arise for sometime to the end special forest maps will ordinarily be confined

(i) Stock maps;
(ii) Management maps;
(iii) Control maps;
(iv) Regional Working Plan maps;
(v) Regional Control maps.

In some cases (ii) and (iii) can be combined, but (i) is always a self contained map recording the actual state of the growing stock at a given date.

2. While it is recognised that it is neither possible nor desirable to standardise orders regarding the preparation and maintenance of special forest maps for the Punjab as a whole it is necessary to issue the instructions which follow for the general guidance of Divisional and Working Plan Officers.

3. The basis of all hill Forest Divisions maps will be the special forest maps whether on the '4", '2" or '1" scale and of Forest Divisions in plains, the Survey of India topographical maps on the '1", '3", and '4" scale, except for such cases for which the Survey of India prepare special forest maps on '4" scale. In the case of Forest Divisions in plains revenue maps are also to be given due consideration. Maps will be reduced or enlarged from the special
forest maps, topographical maps or revenue maps as the case may be, with such topographical details as circumstances and these instructions require. In some cases uncoloured special forest maps will be used.

The symbols in black to be used on these maps will ordinarily correspond in all suitable cases to those laid down in the table annexed to these instructions. Any deviation from these symbols will require previous permission of the Chief Conservator.

4. The only stock maps which are likely to be sufficiently accurate and capable of interpretation in the circumstances prevailing in the forest of the State at present are those showing vegetation types. The stock maps will be forest type stock maps, showing the distribution of the principal forest species, non-forest areas, and blanks. Cases may occur, where management is unusually intense, where density of stocking can be shown with reasonable accuracy, but for some time to come, the forests generally being still very un-even-aged, attempts to indicate age classes on stock maps, are not likely to lead to any useful practical result. Where these general considerations do not apply the Chief Conservator will order such additional detail to be shown on stock maps as is considered desirable in his orders on the Preliminary Working Plan Report. In the case of irrigated plantations preparation of stock maps by age classes, density of stocking any quality classes is compulsory. While preparing the stock maps each species will be allotted a separate colour wash.

5. Stock maps are prepared by Working Plan Officers and submitted with the final draft of the Working Plan or Working schemes. These will, however, ordinarily be printed and a specific order of the Chief Conservator is required before this rule can be departed from.

6. Such maps will ordinarily be prepared on the scale 4" to one mile. These should never be on a scale smaller than 4" to one mile, as it is not possible to show vegetation types with sufficient accuracy on small scale maps; uncoloured printed Forest Survey maps being used: 3 sets will be prepared by the Working Plan Officer,
one for permanent record in the office of the Chief Conservator, one for the use of the Divisional Officer and one for the use of range officers; also where Compartment history files or forest journals are maintained a tracing of the stock map for the Compartment of Forest, as the case may be concerned will be appended in each file.

Owing to the great difference of Zonal vegetative types which are found in this State, it is desired to lay down specific instructions as to the density of stock mapping and the colouring to be used on stock maps for different species. Each Working Plan area will be dealt with on its merits and detailed instructions will be embodied in preliminary working plan reports.

7. Subject to modifications in particular areas it is considered necessary to standardise colours to be used for various kinds of species. The following table shows important vegetation types and a particular colour to be used against each species (based principally on Indian Forest Records Volume I, No. 4: A preliminary survey of the Forest Types of India and Burma by Champeden):

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<th>HIGH HILLS</th>
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In all cases mixtures of types will be shown by coloured hatching, i.e., the area should be given a colour wash of the predominating species and hatching on it should be given of a colour of the species which is less predominant. If it is desired to indicate variations in crop of less-dominating species hatching should be given as under:

- Density below 25%: 
  - Black
- Density 25% to 49%: 
  - Yellow

In the case of irrigated plantations which are to be intensively managed and which are easily divisible into blocks of age classes and blocks of varying density of stocking, it will generally be practicable and even advisable to adopt more elaborate methods of stocking than elsewhere. In this case it will be possible to indicate on stock maps the distribution of age classes and variations in density in addition to vegetation types. This will ordinarily be done by the use of different shades of type colour to indicate age classes and by varying the intensity of colouring to indicate variations in crop density from one line for densities below 25, through hatching for densities between 26 and 50, and cross hatching for densities between 51 and 75, to a full colour wash for densities above 75.
5. To a lesser extent intensive stocking mapping such as that indicated for irrigated plantations may be applicable to Copeace Working Circle and perhaps to Shelterwood Working Circles as the conversion of un-evenaged forest blocks progresses. But such work will only be undertaken in special cases with the approval of the Chief Conservator.

10. Management maps are prepared by Working Measurement Plan Officers to illustrate Working Plans, or Working Schemes. The desirability of their printing in black only at Dehra Dun or in red or blue copies in the office of the Chief Conservator will be decided by the Chief Conservator when passing final orders on the draft.

11. The scale of such maps will be 1” to 1 mile but may vary with the amount of detail to be shown therein. Deviations from the above scale will require Chief Conservator’s orders. Few copies of this map, say up to 3, will be coloured in the office of the Chief Conservator to serve as guide copies and the remaining copies will be coloured by the Circle draftsmen.

12. Management maps will ordinarily show in addition to the main topographical features, such as important woodways, roads, paths of forest importance, Centers of forest importance and the limits of the forest area concerned:

(i) Working circles; (ii) Felling series; (iii) Periodic blocks of shelterwood Circles or Annual coupes of clear felling or Copeace Circles; or areas to be worked in selection circles during the Working Plan Period, where the whole area is not to be worked over; (iv) Compartments and Sub-compartments; (v) Roads and Paths proposed; (vi) Buildings proposed; (vii) Sites of permanent nurseries and sites of permanent sample and experimental plots.

13. It will seldom be necessary to show greater detail than this and the position may arise when even so
many details become unnecessary, but the Chief Conservator may, however, order accordingly; should be deemed desirable, on the preliminary Working Plan report.

14. Each working circle will be coloured separately with a complete wash, areas under regenerative regeneration, if required to be shown, being outlined with an additional hand of the appropriate colour. In practical cases the lighter shades of the colours adopted should be used except in the case where P.B.L areas are to be shown separately. In these cases P.B.L areas should be given darker shade and light shade to areas in other P.B.Ls of the same colour.

15. Control maps are maintained for the purpose of illustrating the progress of forest operations or the occurrence of events of importance in forest management. Where intensive management use of such maps should be encouraged.

16. The annual fire-tracings should be filed at the end of Compartments history files (some times termed forest journals) when such are maintained, otherwise they will be filed separately in the Divisional Offices.

17. Control maps can often be considerably combined with management maps and this should ordinarily be done, but in areas under comparatively intensive management it will generally be advisable to (i) maintain separate control maps and (ii) to have control maps for each Compartments in Compartments history files, prepared from tracings of the Forest Survey Maps by the Working Plan Officers.

18. The purpose of these maps is to show the progress of various forest operations, viz., artificial and natural regeneration, fellings of all kinds, cutting of fire lines and fire tracings, the depredation of fungoid and insect pests, progress in communication and buildings, etc.

19. The various operations are best recorded by different colour washes and combination of colour washes and hatching generally supplemented by entry of the year of operation or completion of the operation on the
maps concerned. The Unit of Control is the compartment or Sub-Compartment if such exist. The mode of record will vary in different cases and no definite instructions are possible for the State as a whole. It will ordinarily be prescribed in Working Plans that such maps should be maintained but where this is not done and a Divisional Officer desires to start a control map, the advice and orders of the Conservator concerned should be obtained beforehand.

20. The great value and importance of control maps whether as separate documents or combined with management maps is brought to the notice of all Conservators and Divisional Officers and it is expected that greater use of this method of control will be made in future.

21. The Regional Working Plans are essentially Soil Regional Working Plan Maps. These Working Plan Maps are made by Conservators. The desirability or otherwise of their printing in black or in red or blue or in green or in brown or any other colour is a matter for the decision of the Conservator and the Chief Conservator when passing final orders on the Preliminary Working Plan Report.

22. The scale of such maps will vary with the amount of detail shown therein, but will ordinarily not be prepared on a scale larger than 1" to 1 mile, only a few cases say up to 3 will be coloured in the office of the Chief Conservator to serve as a colour guide and the remaining copies will be coloured by the circle draftsmen.

23. Regional Working Plan maps will ordinarily show in addition to the important water ways, village boundaries roads, paths of importance, Centres of forests, agriculture and industrial importance:

(i) Water catchments; (ii) Fields or Working series; (iii) Roads and Paths proposed; (iv) Buildings proposed; (v) Sites of afforestation and Chi training Works proposed; (vi) Sites of permanent nurseries and demonstration plots; (vii) Areas closed under sections 4, 8 and 8-A of the Punjab Land Preservation Act (separately); (viii) Areas closed under Section 30 of Indian Forest Act; (ix) Areas proposed for closures under sections 4, 5 and 5-A of the Punjab Land Preservation
Act (separately); (x) Area proposed for closure under section 38 of Indian Forest Act; (xi) Limits of catchments; (xii) Areas proposed for afforestation and other works; (xiii) Areas proposed for terracing and Wadi development.

24. It will seldom be necessary to show greater detail than this and the position may arise when even so much detail may be unnecessary and the Chief Conservator will order accordingly, should he deem desirable, on the preliminary working plan report.

Regional maps. 25. It will be desirable to have control maps for each village pertaining to Regional Working Plans, the basis of which should be the Village revenue maps "SHAHRAS" on scale 1:6 or 1:4 as in force in the area. These maps will show field numbers and field boundaries. These will be maintained for the purpose of illustrating the progress of afforestation, farm training, Wadi development and other works proposed in agricultural lands. These maps should be placed in the Compartments History files or Forest journals, as the case may be.

Up keep of maps. 26. Finally, the attention of all officers concerned is drawn to the importance of maintaining all prescribed maps in good order and all control maps up to date. If control maps are not kept up to date they not only lose their value as showing progress, but become actually misleading. In future, all responsible officers will record, in their official letters forwarding annual Control forms, that prescribed special maps are in good condition and that Control maps have been posted up to date.

PART II

27. Prior to 1883, the Survey of India used to undertake the work of forest survey and mapping the forest area on 1:50,000 scales free of charge. Even supply of survey sheets used to be made free. In 1883, it was decided by the Government of India that local Governments should be debited with the whole cost of work done for them. This procedure remained in vogue till 1904, when the Government of India revised their decision and ordered to share the cost between local Government and survey
or India in the ratio 70 : 30 i.e., 70 per cent to local Government and 30 per cent to Survey of India. The work of forest survey in the Punjab was started by the Imperial Forest Survey of the Government of India in 1877, and the mapping on 4" = 1 mile scale was completed in 1910-11. At this time Superintendent, Forest Surveys of the Government of India was the Captain of the map Records and was responsible for the distribution of maps to various local Governments. In 1922, it was decided by the Government of India that Survey of forest areas would be carried out as part of the topographical surveys which was gradually extended over the whole of India. The normal scale, which was adopted for this Survey was 1" to 1 mile, but in certain undeveloped parts of the country the scale adopted was 1 inch to 1 mile, and in some remote and sparsely populated regions 1/2" to 1 mile. The Forest Department was not required to pay any share of the cost of the topographical survey and mapping. As the ordinary topographical maps were not always sufficient for forest purposes, the scale was too small and a map showing additional forest information, such as the interior boundaries of forests was required or it was necessary to make a special survey record forest boundaries where they did not follow a natural feature, a special survey was to be carried out and special forest maps or boundary maps prepared at the time of the topographical Survey of the area in which the forest was situated, provided:
(a) the Survey of India was informed of the special survey requirements before the month of March of the year in which the topographical Survey took place, and (b) that the Forest Department was prepared to pay for the cost of meeting its requirements, that is, to pay the difference between the actual cost of the survey carried out and that which would have been incurred on the ordinary survey had the forests been surveyed merely to provide the ordinary topographical maps. The Forest Department had to pay the whole cost of the drawing of all special maps if a survey was considered necessary for a forest which was situated in an area which did not come under topographical Survey for some years to come and it was not desirable to wait for maps until the topographical Survey took place or if the forest was situated in an area which had already come under modern topographical Survey and
the existing maps did not meet direct requirements. It was possible for the survey of India to arrange for a special survey on any scale, provided the Forest Department was prepared to pay the entire cost of the survey and mapping. But such special surveys of forests which could not be carried out as part of a survey Party's ordinary programme were necessarily expensive and affected seriously the normal operations of the Survey of India.

28. In 1935 Government of India, vide their letter No. 7-43/53-F, dated 17th February 1935, revised the above procedure due to the burden of the numerous demands from several quarters for special project surveys. A high powered priorities Committee was appointed by the Government of India. A committee had been set up in 1935 with representatives of all interests concerned. The main function of the body was to decide and allot priorities and approve the annual programme of work for the Survey of India consistent with the requirements of the Five-Year Plan and other overall national interests. Except for the high-kilometre areas in the North, which are to be surveyed on the half-inch scale, Government of India have decided that one-inch to a mile would be the normal scale of mapping for the whole of India. Highly industrialised areas and areas of importance from the defence of other points of view are to be surveyed on the scale of 1:25,000 when the progress on the one-inch map permits.

29. All the forest areas are therefore to be surveyed on the one-inch scale by the Survey of India as part of their normal work and the one-inch maps containing forest areas will be available on payment at the current price for this type of maps. Forest Department will not be required to pay any share of the cost of these one-inch surveys. Even though the external boundaries of forests, if demarcated prior to the commencement of a survey of the area, are to be shown on the one-inch maps, it has been found from experience that this scale is too small to show all the information which forest officers normally require. Surveys on the larger scale of 4-inch to a mile showing interior boundaries of the forests and other details from the forestry point of view would be necessary. In this case the entire cost of preparation of these large scale maps is to be paid by the Forest Department concerned. If, however, these special maps are asked for at the time when the
Survey of India are about to survey the area as part of their national programme, the cost of the one-inch survey, which the Survey of India, would in any case have incurred, is to be deducted from the cost of preparing the larger scale maps for the Forest Department. The departmental rules of the Forest Department and the Survey of India provide for necessary consultation between the Heads of Forest Departments and Directors of the Survey of India so that the former are kept informed about the progress of forecast of the topographical survey programme two years in advance. It might therefore be possible for the Forest Department to avail themselves of the opportunity to get their forest areas surveyed simultaneously with the normal topographical survey and thereby obtain a reduction in the cost of their forest surveys. It should be noted that the Survey of India requires information about the inclusion of such surveys which must be communicated to the Survey of India before the month of March preceding the field season which commences in October of the same year. Conservators of Forests are therefore advised to submit a return in the month of January each year, if any forest area is required to be surveyed on a bigger scale.

30. There may be cases in which the Forest Department want the survey of India to undertake special surveys of areas which have already been surveyed by them for the one-inch scale after 1968 and for which contour maps already exists. As such areas will not come up to topographical survey the procedure is as under:

The survey of India is subject to the very large number of demands for surveys placed on the Survey of India and the limited resources of the Department to undertake the work, a meeting of the priorities Committee referred to above is held periodically to allot priorities after scrutinising the demands. The number of Party years for Forest Surveys are allotted at this meeting. While framing their annual programme the Survey of India keep these allocations in view and inform the State Governments concerned in July what forest areas would be taken up for survey during the ensuing field season and indicate the cost of such surveys. The Heads of Forest Departments have to certify that they
accept the estimates and have adequate funds to meet the cost of these special surveys. These certificates are to reach the Survey of India at the latest by the 15th September to enable them to take up the work. It is to be noted that if the certificates are not submitted in time, the Survey of India may have to drop the special survey from their programmes, and it may also be difficult to fit it in their future programme. The Department may have to wait till any party years are again allotted for the area concerned. As the outturn of survey in any area depends upon the nature of the tract of the land (terrain) and the cost of survey varies with the outturn in any particular area, it is not possible to give any precise estimate of cost of forest surveys. However, with a view to assist the State Governments to make necessary provision in their budgets, it may be stated that the outturn in respect of 4 inch surveys may be taken as Rs. 800–900 square miles per Party year and the cost about Rs. 1,500 per square mile. The Survey of India will, of course, charge the actual expenditure incurred in each case. The symbols by which the various items of information will henceforth be shown on the special forest maps have been standardised and a copy of the symbol table is appended at the end of this order. The maps will only show the information as standardised.

31. The following rules, summarise the procedure to be followed in connection with special forest surveys executed by the Survey of India—

(i) Except when the Survey of India are asked to make a special Survey of a forest, all forest areas will be surveyed on the scale adopted for the topographical survey of the region in which they are situated. The resulting topographical sheets can be obtained by purchase on identical about a year after the completion of the Survey from the Director, Map, Publication, Survey of India, Rashtrapahali, Delhi.
(ii) When the topographical maps as prepared by the Survey of India as part of their normal programme do not satisfy the requirements of the Forest Department, a special forest survey can be carried out and a special forest map prepared for any forest area or any portion of it situated within the ordinary programme of a topographical survey party, provided that the Forest Department is prepared to pay for the additional cost of the work.

(iii) When the survey of a forest or of a forest boundary is considered urgent and the area to be surveyed does not fall in the programme of the topographic survey of the Survey of India, the demand is to be submitted to the Government of India in the administrative Ministry concerned and to the Survey of India, when arrangements will be made for their inclusion in the programme of project surveys as decided at the Survey Priorities Committee. The entire cost of such surveys will be met by the State Government concerned.

32. In 1906, which marks an important turning point in the history of India's maps, it was decided to maintain a separate Forest Map Office in the office of Survey of India to be started and run on the contribution of various States. Every State was required to contribute according to its forest area. The functions of the Forest Map Office, Dehra Dun were:

(i) to maintain the stock of forest maps;
(ii) to keep up-to-date the Port folio set of maps after obtaining necessary information from Divisional Forest Officers of various Provinces;
(iii) to arrange the distribution of maps on receipt of orders from States concerned; and
(iv) to prepare various kinds of maps, i.e., Working Plan maps, Working Scheme maps, and other maps required by any State.

33. The system then in vogue was that the respective States used to send colored maps to the Forest Map Office.
office, Dehra Dun, which used to print them in colours as well as in black after preparing negatives in their own office. The cost of preparing and printing maps then was very high. It used to charge maintenance cost from various States but in case the maps were required by any Department other than Forest Department or any private firm, it used to charge price for these maps and to credit it to their own office. A little before the partition, some States felt that it was inconvenient and uneconomical to allow their maps maintained in the Forest Map Office, Dehra Dun at a high cost. They, therefore, withdrew their maps and began to maintain their stock of maps in their own offices. Punjab was one of these States. Since then, the stock of maps is being maintained in Chief Conservator of Forest's Office at a very low cost and the following work is being done in the Office of the Chief Conservator of Forests, Punjab, in connection with these maps:

(1) There is one portfolio of maps on 4"=1 mile scale, covering the area for which this scale maps are available. These maps show all changes since the time when Forest Map Office at Dehra Dun was started. Every year Divisional Forest Officers are required to submit their maps showing all changes during the year. The following programme gives the dates when each Divisional Forest Officer must submit his maps:

1. Amritsar Forest Division
   Date: 1st week of December
2. Ludhiana
   Date: 1st week of January
3. Jalandhar
   Date: 1st week of February
4. Ambala
   Date: 1st week of March
5. Kangra-Shillong Forest Division
   Date: 1st week of April
6. Chamba-Hamirpur Forest Division
   Date: 1st week of May
7. Sirmour Forest Division
   Date: 1st week of June
8. Kangra
   Date: 1st week of July
9. Bilaspur
   Date: 1st week of August
10. Mandi
    Date: 1st week of September
11. Una
    Date: 1st week of October
12. Solan
    Date: 1st week of November
Divisional Forest Officers are required to submit their maps showing all changes which have taken place during the year, e.g., all changes in areas, viz., deforestation, afforestation, additions, and subtraction of areas closed under section 38 of Indian Forest Act and sections 4 and 5 of Land Preservation Act (they are also to be indicated in the margin of Survey Sheets supported by authority governing such changes), roads, boundaries, buildings, etc.

(ii) Survey Sheets on 4'\text{1} \text{ mile} \ text{ scale which are likely to go out of stock in the near future are got reprinted from Map Publication Office, Dehra Dun. It has been possible to effect considerable economy by sending, (a) a copy of portfolio map to the Map Office, Dehra Dun; and (b) a copy of blank Survey Sheet to serve as original, showing the required details. From the original, which has to be in black only, it is very easy for the Map Office, Dehra Dun, to reprint new edition of any Survey Sheet by photomicrography method. By this method, Survey Sheets are reprinted at a cost varying from Re. 2 to Re. 4 per sheet, if 100 copies of the Survey Sheet are reprinted. In case every thing is left to the Map Publication Office to prepare original from the portfolio copy in their own office the cost per copy may range from Re. 10 to Re. 60 as the case may be. The cost (high or low) also depends on the number of copies to be printed, i.e., if the number of copies to be reprinted is high, the cost per copy goes down and if the number of copies to be reprinted is low the cost per copy is likely to rise. All aspects are, therefore, kept in view when the reprinting is to be ordered. Every time the maps are reprinted it is necessary for the Head Drafterman of the Office of Chief Conservator of Forests to go to Dehra Dun to explain verbally to the Map Office the details to be printed on new sheets. This arrangement has proved very satisfactory and has been appreciated by the Map Office, Dehra Dun as well. Before the reprinting of any sheet is undertaken a portfolio copy of the Survey Sheet to be reprinted is sent to the Forest Division concerned to check the details required to appear on the reprints.

(iii) Special Forest Survey Sheets on 4'\text{1} \text{ mile} \ text{ scale are supplied to Conservators of Forests and}
Divisional Forest Officers on receipt of their Indent in the following form:

**INDENT No.** ...... **date.** ...... 189 ...... for the Special Forest Maps, which should be sent to the Office of the Chief Conservator of Forests, Punjab, Simla.

<table>
<thead>
<tr>
<th>Indent No.</th>
<th>Receiving officer and date</th>
<th>Seal</th>
<th>Number of copies ordered to be sent to the issuing office</th>
<th>Number of copies now required</th>
<th>Reason for requiring new supply</th>
<th>Remarks</th>
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</table>

- Note: Blank forms are obtainable from the Office of Chief Conservator of Forests, Punjab, Simla.

(iv) Survey Sheets which can be spared easily from the stock of the Office of Chief Conservator of Forests, Punjab, are sold to Government Offices other than the Forest Department of this State, at a price fixed by Chief Conservator of Forests from time to time with due regard to current price of paper and printing charges. At present, the price has been fixed at Rs. 5 per uncoloured Survey Sheet on 4" = 1 mile scale. Survey Sheets which fall under the restricted category are sold for official use only on obtaining the following prescribed certificate:

**CERTIFICATE**

I, ______ (name) ______ agree that the supply to me by the Chief Conservator of Forests Punjab (I) of the aforementioned "Restricted" Sheet/Sheets is/are subject to the following conditions which I hereby undertake to observe.
(1) The sheets will be treated as very confidential and I will take every reasonable precaution to prevent their being lost.

(2) No sheet will be reproduced in part or in whole either by photography or by any other means.

(3) If called upon to do so, I will return, through proper channel the sheet/sheets to Director of Military Survey, or Director of Military Intelligence, or their duly authorised representative.

(4) I will immediately report through proper channel the loss of any of the sheet, to the Director of Military Intelligence, Army Headquarters, New Delhi.

<table>
<thead>
<tr>
<th>Sheet No.</th>
<th>Number of copies</th>
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Place: __________________ Signature: __________________
Date: ________________ Address: ___________________

(v) Survey sheets (Scale 1\(\frac{1}{4}\) mile) which do not fall under the restricted category are available for supply to public at a price fixed by Chief Conservator of Forests, Punjab, from time to time.

(vi) Survey sheets (Scale 4\(\frac{1}{2}\) mile), are sold in black only. If any purchaser wants the colouring to be done in the Office of the Chief Conservator of Forests, Punjab, the cost of labour and materials is charged.

(vii) Copies of Working Scheme Maps, which are not printed at Dehra Dun, are printed in the Office of Chief Conservator of Forests, Punjab, by the following methods:
(a) Pero.
(b) Deno.
(c) Azo.
The procedure is that negatives in black are prepared by Circle Draftsmen and submitted to the Office of Chief Conservator of Forests wrapped on rollers. Great care is to be taken to see that no colour wash appears on the negative and the negative, of which copies are to be printed, are not folded. It will be decided by the Chief Conservator of Forests at the time of passing orders on the preliminary report, what number of copies are to be printed if the map is not to be printed at Dehra Dun.

(viii) Working Plan. Maps are not printed at Dehra Dun by the following methods:

(a) **VANDYKE**
(b) **HELIΟZINCOGRAPH**
(c) **PHOTOZINCOGRAPH**
(d) **LITHOGRAPH**

The procedure is that Working Plan maps received in Chief Conservator of Forests' office from Working Plan Officers through their respective Conservators of Forests are checked with the script of the draft plan and their negatives are prepared in the office of the Chief Conservator of Forests for getting the maps printed at Dehra Dun. The maps are printed in black only to save high cost of getting maps printed in colours and colouring is done by the Circle Draftsmen from colour guide supplied by the office of Chief Conservator of Forests. If any map is necessary required to be printed in colours, the negative showing all details in black along with a colour guide are sent to the Map Office, Dehra Dun. With this procedure the cost of printing maps in colours is likely to be less. But in case the Map Office, Dehra Dun, is asked to prepare the negative the cost might go up 10 times as when negative is prepared in the office of Chief Conservator of Forests. While sending a requisition of printing any map Chief Conservator of Forests will decide the number of copies to be printed.
34. Under the 1905 Scheme the whole of Southern Asia was divided into sheets of suitable sizes for various scales and a definite programme was drawn up for the mapping of this area on large scales to form a topographical series. The topographical scales decided on were 1 inch to 1 mile, ½ inch to 1 mile and ¼ inch to 1 mile. The layout and numbering of all topographical maps are based on the 1/10M or 1/1,000,000 India and adjacent Countries series maps. Each 1/10M map is divided into sixteen 1½ sheets; each ½ sheet is divided into four 1-inch sheets and each 1-inch sheet is divided into four ¼-inch sheets. On the scale of 1 inch to 1 mile each sheet covers 1° of latitude by 1° of longitude, that is four times the area covered by a ½ inch map. Contours are generally at 250 feet intervals. These sheets are sometimes referred to as "degree sheets.

35. On the scale of ½ inch to 1 mile, each sheet covers 30° of longitude by 30° of latitude, that is four times the area covered by a 1-inch sheet. Contours are generally at 100 feet intervals.

36. On the scale of 1 inch to 1 mile, each sheet covers 15° of longitude by 15° of latitude. Contours are generally at 50 feet intervals. These sheets are the standard tactical maps and all important areas have been or will be surveyed on this scale.

37. Maps of certain areas of all scales published by the Survey of India are classified as "Restricted." Restricted maps are not available to the public. Applications for topographical restricted maps for official use only should be made on the prescribed form No. 59(b), obtainable from the Director, Map Publication Office, Dehra Dun and maps can only be supplied on fulfilling the terms and conditions noted on the indent form. Indents of topographical maps should be submitted to Chief Conservator of Forests for their transmission to the Director, Map Publication Office, Dehra Dun.

38. Application for special forest maps on 1 inch = 1 mile scale of restricted area for official use should be made to the Chief Conservator of Forests, Punjab, Sialkot.
<table>
<thead>
<tr>
<th>No.</th>
<th>Symbol</th>
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<tr>
<td>2</td>
<td></td>
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<td>3</td>
<td></td>
<td>District</td>
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<td>4</td>
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<td>Subdivision (Census, Relief)</td>
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<td>5</td>
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<td></td>
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<td>8</td>
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<td>Tika</td>
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<tr>
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<td>Terracing &amp; Way Bandi</td>
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<tr>
<td>22</td>
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<td>Railway line with station</td>
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<tr>
<td>23</td>
<td></td>
<td>Road metalled with mule stone</td>
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<tr>
<td>24</td>
<td></td>
<td>Unmetalled</td>
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<tr>
<td>25</td>
<td></td>
<td>Cart road</td>
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<td>26</td>
<td></td>
<td>Mule or bridle path</td>
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<tr>
<td>27</td>
<td></td>
<td>Inspection path</td>
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<tr>
<td>28</td>
<td></td>
<td>Foot path</td>
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TECHNICAL ORDER NO. 8

PROTECTION AGAINST DAMAGE BY FIRE

The following general instructions are issued for the guidance of Forest Officers, their application will necessarily vary from place to place according to the locality and the type of forest. On the one hand fire is fire resistant but still needs protection in the seeding stage, and is destroyed by incendiary fires in the hot, dry weather. On the other hand deodar and still more so blue pine, spruce and silver fir are not fire resistant and the silver fir is killed nearly by the heat from a burning pile of ash. There is less danger of fire in mixed crops especially in a mixture of broad-leaved trees and conifers and in deodar and blue pines; scrub-areas may escape damage for years but after a heavy frost they may become very inflammable. In the Punjab strict preventive measures are essential to a greater or lesser degree in the case of all forests whether in the hills or the plains.

2. Fires are either accidental or deliberate. The causes of fires are these:

(1) Accidental: common causes are, lighting fires by travellers, shepherds and labourers; they are sometimes caused by sparks from railway engines; sometimes by carelessness in throwing away cigarette ends, accidents in silviculture burning, charcoal burning, by sparks caused by falling stones and by lightning; frequently they are lit from motives of revenge, for political reasons or from pure mischief; sometimes to drive away wild animals or to conceal crime. It is a fact that accidental fires can be dealt with and brought under control without difficulty. In the case of wanton, incendiary it is quite impossible to take adequate measures to cope with the conflagration. Fires being, therefore, sooner or later inevitable, it remains to take such adequate steps as lie in the power of the Forest Officer to mitigate this ever present danger and to reduce the fire hazard to the absolute minimum by all methods within our power.

3. The greatest danger from fire occurs during the fire season. The fire season in the months of April, May and June and until the south-west monsoon breaks in early July. During the autumn there
is ordinarily less danger from fire but the forests are not
safe until after the first heavy fall of snow.

4. The practice of scientific forestry is impossible
when there is enmity between the local people and the
Forest Staff, as the forests are so inflammable that the re-
sults of years of effort can be destroyed by one fire. The
Divisional Forest Officer and Range Officer must tour
regularly through the forest area and must be accessible
to local villagers and deal promptly on the spot with all
complaints. It is essential that relations with local
inhabitants should be friendly and these are secured
only when rights recorded in Forest Settlements are
fully satisfied and the obtaining of permits for forest
produce is facilitated. Many forms of minor produce
are of no value for export but are of use to the local
inhabitants and their removal can often be permitted.
A contended peasantry and willing co-operation be-
 tween them and the Forest Staff are the first essentials
for successful fire protection.

5. The chief demand of the villagers is for grazing,
particularly in the areas close to villages, and it is essential
to allot periodic blocks in forests under a regular
system of management so to afford reasonable facilities
for grazing by the flocks and herds of all right-holders.
An undue concentration of regeneration falling is to be
avoided.

6. Closures to grazing are necessary in the interests
of regeneration, but care must be taken to enforce
closures only against practices which are definitely harm-
ful, the cutting of grass and bushes should be permitted as
soon as the seedlings are established, and grazing by lim-
ited numbers of cattle, but not by sheep and goats, should
be allowed when the plants are two or three feet high in
order to reduce inflammable undergrowth. As soon as
the plants have grown sufficiently to be out of the reach
of sheep and goats these animals should be admitted where
they have recorded rights, but not elsewhere: buffaloes
should never be allowed in areas free from rights. The
removal of fallen pine needles for litter should be allowed
in pine forests as the inflammability of the soil covering
is thereby reduced. Cattle grazing should be permitted
in regeneration areas and in reserved forests free from
rights where undergrowth is dense where such grazing can do no harm.

7. The harmful effects of fires in pole woods and semi-mature forests where grass and bushes are kept in check by cattle grazing are markedly less than in forests closed to grazing, and it is now recognised, that a lowering in the quality of the locality and a consequent retardation in the growth of the crop due to grazing are far to be preferred to the risk of complete destruction by fire. Excessive grazing and browsing are, however, definitely harmful and lead to serious erosion and cannot be condoned.

8. The prevention of the entry of fire from outside is a matter of considerable difficulty. Fire patrols, the erection of notice boards, and the enforcement of rules and legal remedies are resorted to as a matter of course. Standard notices should be posted along public roads passing through the forests. Sight-builders, conservators, of forest produce, and Government officials are bound to furnish help to extinguish a forest fire whether called out by a forest officer or not and may not be permitted to evade their responsibility. In the inner hills there are extensive grasslands bordering on the forests which produce a dense crop of grass during the monsoon. Part of this is cut and harvested and part is grazed, but much is left standing and when it dries, is very liable to catch fire. In unburnt pastures dead grass accumulates and the production of green grass in the spring is hampered; consequently the grass lands are burnt under control during the winter when the neighboring forests are either under snow or are so damp as to render very small the risk of their catching fire. The burnt grass lands form very efficient fire tracery during the spring and are of prime importance in reducing the fire hazard.

9. Exterior fire lines are kept clear of undergrowth, either by cutting or by burning, but in order to be effective they must be correctly located along ridges or along horizontal belts below the forests. The cost of efficient upkeep is, however, high and as needles fall during the hot weather when the danger from fire is greatest, their value as automatic checks to fire is, to say the least, problematical. They form, however, lines from which fire fighting operations can be initiated, and
their value is increased when paths along them add mobility to the labour force. Of great importance is the fact that on cut lines, the labour force can be effectively supervised and concentrated at spots where the fire is spreading rapidly. Boundary lines are kept clear of undergrowth and to some extent are substitutes for regular fire lines.

10. The sub-division of large blocks of forest and the isolation of plantations by cut lines are essential in order to render it possible to localize fires. Interior fire lines in the hills must run along ridges and along them must be constructed small foot-paths. These must be connected by level foot-paths, as thereby not only the area is divided into units of manageable size, but a labour force is rendered mobile and enabled to proceed with speed to the site of the out-break of fire. A fire can usually be extinguished provided that labourers can reach the spot before it has spread over a wide area and speed of movement is the first essential to successful fire extinguishing. These contour paths and fire lines along ridges also serve as bases from which counter-fire can be started with the object of containing the out-break of definite limits. At present all that can be attempted is the horizontal division of the more valuable forests into three portions by means of level paths through the lower and upper halves of the forest—further sub-division, though desirable, will only be possible after some years on account of expense. The roads and compartment lines of the irrigated plantations serve as interior fire lines.

11. The reduction of the inflammability of a forest throughout its life is essential, and the foundations of immobility from the more serious effects of fire are laid with the first seeding felling, which must be as heavy as the silvicultural requirements of the species permit, in order to allow of the burning of the very extensive refuse from conversion. A clean seed bed is essential to subsequent fire protection. The refuse from secondary and final fellings cannot ordinarily be burnt in situ but must be removed by hand, thrown into nullah beds or burnt on blankets or merely piled and left to decay. Plantations should be confined between fire lines, or should end, at definite nullahs, and their lower edges should border on contour paths.
12. All roads open to trade, traversing the forests, should be swept of needles during the hot weather. In forests and in mixed deodar and kail forests, under plantation belts of pure deodar should be established on all paths and outer boundaries, as pure deodar woods are much less likely to catch fire or to be destroyed by fire that are mixed deodar and kail or pure kail forests.

13. The growing of pure kail woods is not an economic proposition on account of the danger of fire. Kail must be mixed, preferably with deodar.

14. The use of grazing, grass cutting and the removal of fallen needles for litter in areas under regeneration has been referred to above. Young seedlings must be separated out at a very early age and the cut plants got rid of; by the time the young plants are four or five feet high their average distance apart should be about 3 to 4 feet. Early thinnings in pure woods reduce the danger from fire provided that the cut material is got rid of. The extent to which suppressed and dominated trees are fallen in thinnings is referred to in technical order No. 1—Thinnings.

15. The chur forms a thick bark at a very early age which enables it to resist the effects of a slow fire and this property has been taken advantage of during the past forty years which have witnessed the introduction and development of controlled firing.

16. It was proved by extensive experiments that chur woods could be burnt after winter rains by fires constrained to move progressively in a down hill direction without appreciable damage to pole crops. Not only are the villagers rendered more content with forest management by reason of the improvement in grass and grazing but the forests are rendered comparatively immune from the effects of fires during the hot weather owing to the reduction of the inflammable soil covering.

17. All regeneration areas must be isolated by fire traces until they are sufficiently advanced to be fixed permanently. Interior fire lines must be cleared of grass in order to enable fires to be localised. The chur seedling develops a thick bark by the time it is four or five feet in height which enables it to resist the effects of a slow fire.
during the winter. The foundations of successful fire-protection are laid with the first seeding - fellings which must extend evenly over the whole compartment under regeneration, apart from compact groups of poles which are left intact.

When the seedlings are from two to three feet in height the grazing by cattle should be permitted in order that the inflammable grass may be reduced; grass-cutting may be allowed when the seedlings are considered by the Divisional Forest Officer to be large enough not to be cut along with the grass; that is when they have developed a coryb leaf. But it must be noted that very young seedlings are normally cut by grass cutters, and that this has proved to be a reason for the failure of some areas to regenerate. The young plants must be thinned to a distance of 3 feet when about three to four feet in height and the cut material removed from the regeneration area.

17. After the foregoing means of reducing inflammability have been employed and the plants have developed a thick bark a controlled fire shall be started after winter rain has been constrained to travel only in a downhill direction, any patches of young seedlings being protected from being burnt. The age and height which the plants must attain before they can resist the effects of a slow fire vary according to the moisture content of the soil which again depends on aspect and elevation; ordinarily speaking the regeneration on cool aspects and in moist situations may be burnt without control when three to four feet in height; on warm aspects the first controlled fires must be delayed. All controlled burning must be completed by the end of February.

18. Along ridges and level paths narrow traces are cleared of needles and a fire is started on the lower side and moved to burn down hill only. Sufficient men must be present, armed with small branches for beating out the fire in the event of its jumping the trace. The fire burns slowly down hill and after it has burnt a few yards the trace may be left under the watch of only a very few men and a fresh trace started some little way down the hill and a second fire started below it in order to expedite operations. Subsidiary ridges are used as base lines for starting similar fires. Throughout the operation the line of fire
should be kept as straight as possible and a few men must remain below it, particularly where the ground is steep, in order to extinguish at once fires caused by rolling cause. Operations must be so planned as to cease by night. Fire-fighting parties must then be confined to places where the fire can burn itself out without fear of extending to other forests, and two or three men must keep watch. Burning is safe during the winter months December to February and should commence as soon as the soil covering has dried out sufficiently after winter rain. Villagers are glad to give help free during the day as they benefit from the improved growth of the grass after fire and they should be consulted as to the dates when firing is convenient and as to the area to be burnt as it is undesirable to burn the whole of a village's grazing ground until there is no further need of winter fodder. Night watchers may be paid a small fee.

In forests tapped for resin it is difficult to prevent the resin blowing off the bases of the trees and to prevent this, the bases of the trees must be cleared of needles, chips and resin by the tapping colleges at the end of the season. The ground at the bases of the trees must be left absolutely clean to a radius of four feet.

19. Resin tapping colleges must be present throughout the operation of controlled burning; preferably this duty should form part of their contract without additional payment, but if this cannot be arranged their attendance must be paid for and charged to resin expenditure. Local villagers cannot be expected to take sufficient interest to prevent the resin blowing catching fire.

20. During the fire season and particularly where the Organisation for fighting fires is not effective, the forests should be frequently patrolled by the whole of the forest staff, occasionally a night patrol should go round and every one found moving in the forest should be questioned. Every guard should look on his post as his own property and he should be considered personally responsible for its safety. Men can only be judged by their works, and inability to obtain immunity from fire will count against a man's record.

21. When a fire is observed, Forest Guards and Fire watchers at 'look out' points should at once send a message...
to the Range Officer. They should immediately inform all Lambardars and Chawkiddars of the right and concession holding villagers in the vicinity as well as contractors and workers in charge of gangs of labourers working near the scene of the fire. The senior officer present will immediately take command of the operations. He should know the local geography and have some idea of the labour force present and he should organise his labour in sections each under the orders of one man and should allot them, definite tasks. He should keep a couple of men in waiting to take messages and instructions to the various sections. Should a fire get beyond control, it is necessary to localise it by countering. Countering should only be done under orders of the senior officer in charge of operations and should only be attempted from a defined line such as a road or ridge or fire line. A line is formed along a ridge by clearing the soil covering and cutting bushes from which a fire is started so as to consume the fuel in advance of the oncoming forest fire. Roads are even more useful to countering from and even a narrow path is sufficient provided enough men are present. After the fire has been brought under control a roll should be taken of all villagers present so that absences can be prosecuted.

A patrol is to be kept on duty until all danger of the fire spreading has been removed.

22. Each range should have a written plan of operations in case of an outbreak of fire and every member of the staff should have definite instructions exactly what is expected of him until the arrival of his senior officer.

23. Arrangements for the transport of food and for water and tools are essential and these matters must receive adequate thought and be provided for.

24. Proved cases of incendiaries should be punished with the utmost severity. Prosecutions under sections 26 and 32 of the Indian Forests Act are of little use in such cases and action should be taken under section 435 of the Indian Penal Code. The Divisional Officer should himself inquire into such cases and if necessary conduct the case for the prosecution before the Magistrate and press for an adequate penalty.
TECHNICAL ORDER No. 9.
DEPARTMENTAL EXPLOITATION.

General.

Timber work has now become very specialised, and although conditions of labour and methods of extraction must vary, the general principles and orders which follow will be found to contain points which cover all forms of departmental exploitation. Each phase of the work must be kept separate and falling, sawing, cartage and floating should be distinct operations carried out under proper supervision.

Felling.

2. The chief considerations when felling a tree are: (a) to direct the fall in a direction where least damage is likely to occur to the standing crop, (b) to prevent the tree from breaking up, and (c) to prevent wastage of good timber.

3. Where there is no possibility of damage to regeneration or young trees, branching, or as it is commonly called lopping, is unnecessary, in fact the retention of branches is an advantage as they act like cushions and break the fall of a tree. No lopping is usually necessary on trees marked in seeding fellings, but lopping should invariably be done where secondary and final fellings are being carried out. When inspecting felled and lopped trees it is as well to remember that branches which have the cut on the underneath side have obviously been lopped after felling. On steep ground the outside and heavy branches should be lopped. These have a tendency to pull the tree over.

4. As a rule all trees should be felled straight uphill, but where the ground is very steep, fellings should be made in vertical strips and the trees felled "herring bone" fashion. The reason for this is that if the trees
begins to slip or roll there is every likelihood of their being held up by standing trees. Felling along the contour in undulating ground results in the trees breaking their backs and great damage to the timber. (See diagram.)

Diagram No. 6.
Felling should always commence at the top of the forest and proceed downhill and all trees should be felled so as to lie parallel to each other.

5. There are two methods of felling a tree:
   (1) Axe.
   (2) Saw.
   (1) Felling with an axe is the more common and is only recently that the saw has been introduced. It is not, however, always possible to use a saw, as for instance on trees growing on the edge of the high fields or where the ground below the tree dips suddenly.

Diagram No. 7.
It is impossible for men standing at A and B to use a saw.
6. The initial cut with an axe is made on the side which the tree is to fall and is carried through to about 2/3 of the tree. In big trees the inner cut may be as much as 1/3 of the tree. The centre of gravity of the tree must be cut through by the inner cut. The next cut is made exactly opposite to this cut and about 4" to 6" above it. Both cuts must be parallel to each other otherwise the tree will deviate from the desired direction of fall. Diagrams 8 and 9 show how the cut should be made and the appearance of the stump after the tree has been felled.

Diagram No. 8. Diagram No. 9.

7. When using a saw a small inner cut is made low down on the stump and not more than 1/8 of the diameter of the tree. The outer cut is then made with the saw exactly opposite the bottom of the inner cut and as soon as this cut is deep enough, two wedges are inserted and hammered in as sawing proceeds. Unless a rope is used the fall is directed by hammering the wedge away from the side in which it is proposed to drop the tree. Using a saw usually saves about 2 feet of the butt log, the most valuable part of the tree.
made in the right place. All members of the staff employed on felling should know how the work is done and for preference should be moderately proficient in the use of the felling axe themselves.

When the tree is felled the man in charge forwards it off on his marking list, puts the name of the feller against the tree and enters up details of lopping and roping, which are now paid for in addition to felling. At the end of the day he prepares an abstract of all trees felled, roped and lopped, and gives it to the Forester, or Deputy Ranger, in charge of that particular block of exploitation, who enters it in the proper register.

LOGGING AND SAVING

12. When all trees have been felled the forest is divided into sections or "ghalis" by the sawing contractor, who makes each man responsible for the conversion of all trees in his particular "ghali". In divisions where go-down is issued departmentally, it is always advisable to keep a section or two in reserve for the more rapid workers otherwise those who finish first, will have nothing to help them earn their rations.

13. The Divisional Forest Officer receives, annually from the Conservator of Forests, a list of the market sizes most in demand and the quantities of each species which the market can absorb. On the market demand depends his instructions to the Range Officers or Exploitation Officers.

14. When the main demand is for sleepers he will issue orders accordingly, taking care to see that the longer lengths of nail and chill are always given preference. No rules can be fixed as the logging of trees into various lengths depends entirely on the market requirements.

15. Each tree must be marked off, personally, by the logging and sawing man in charge of an exploitation block, who must be given a list of the sizes to be cut for each species and in the order of importance. If this is not done, the sawyer will log the tree into sizes most remunerative to him, regardless of what the market requires. All logging must start from the butt end of the tree.

16. All logging of all species must be done with cross-cut saws which are provided for the purpose; the sawing of trees into logs is absolutely prohibited and any workman found doing this should be fined at once. Under no circumstances should explosives be used for splitting very large.
logs; more often than not, the whole log gets "shivered" and is rendered useless for conversion into sleepers. It is better to pay the mani according to the size of the log and to make him split the log with wood and iron wedges.

On steep ground pits should be dug for the first or three heavy logs otherwise they are liable to career, mauls, downhill, breaking up sawn timber and generally causing destruction.

Diagram No. 11.

17. In marking off logs for sawing it should always be endeavoured to avoid centre heart in all kinds of B. G. sleepers. The Railway will not accept B. G. sleepers of chill and fir with centre heart and the presence of centre heart results in excessive degrade. Small trees only capable of giving one scantling of sleeper section (10"×3") should never be converted into Railway sleepers. If a line is first drawn through the centre of large logs before squaring, it is generally possible to obtain exactly the same number of scantlings devoid of this defect.

18. In diagram 12 a little manipulation in squaring the log has given 4 B. G. sleepers and 1 harr without centre heart whereas if the log had been squared in the
ordinary way one R.G. would have contained centre heart.

Diagram No. 12.

Again, centre heart can be avoided in a log which is to give 3 sleepers by sawing the squared log as in Diagram 14. If sawn as in Diagram 13, the middle sleeper will contain centre heart.


19. Some very old trees contain rot in the centre heart and for some distance round. To saw through this will give 2 sleepers containing rot. The centre heart and rot should be sawn out in one sleeper. After marking out the timber at the thin end of the log the mistri squares the log and hands it over to the sawyers with the sizes properly marked out in full with his measuring line.

20. The mistries and sawyers usually have measuring sticks called karphas. These are thin sticks cut to the sectional sizes of the various sleepers. It is important that the Forester or person in charge measure these karphas once a week to see that they are of the right size. The sawyers, very foolishly, make these from green twigs and
when dry they are invariably underestimé and end in sleepers being rejected.

21. Sawn timber is stacked at each pit and is inspected by the official in charge of exploitation. He must satisfy himself that the sleeper is of the correct size including the extra allowance for Forest Depot as opposed to Sales Depot sizes. He then hammer marks the sleeper with the Government property mark, and any other mark according to the standing orders of the division. All passing should be done in the presence of the contractor or his authorized agent. The passed and rejected sleepers are entered up in the register against the name of the mistrees and the sawyers and brought on the Form No. 7 (Forest Depots). Kiln timber dries out very quickly and sawyers always cut this timber well oversized so as to avoid rejections in the event of delayed passing. After passing, all timber should be retacked in order to keep it out of harm's way from rolling logs or falling trees and also to facilitate location in the event of early and heavy snowfall. All sleepers must be kept in the shade or covered with earth so as to prevent cracks developing and steps must be taken to protect the ends from the sun. The cutting of oversize sleepers must not be encouraged because, eventually, carriage labour will demand increased rates for handling appreciably heavier timber.

Carriage

Land Carriage. 22. Before allowing the carriage contractor to start work the carriage leads are measured. The usual method of calculating these leads or fires is to measure (in chains) the lead from the topmost stump to the bottom boundary of the compartment and to allow from $\frac{1}{3}$ to $\frac{1}{2}$ of the total length at the full rate. The lead outside the forest which is being exploited is paid for in full without any deduction and is called added fire. The Divisional Forest Officer is responsible for the correctness of the carriage fires. The sleepers are then carried down to the logging depots and stacked according to species and sizes. Beams cannot be carried and these are dragged by means of a rope and spike fixed into
23. The form of rope-way used in the "Punjab" was evolved by Mr. C. H. Donald under the name, "The Timber Carrier" (Indian Patents Nos. 234 of 1812 and 1064 of 1913). Technical Order No. 15 gives an exhaustive description of these rope-ways which should be carefully consulted. This particular form of rope-way has many advantages. It is cheap, portable and simple to operate. It can be erected for the carriage of a few thousand sleepers and can be controlled by ordinary unskilled labour in charge of a capable man. The ordinary span varies from 1,500 to 3,000 feet and larger spans are not recommended. The maximum load is 13 cubic feet but for every day working the limit has been fixed at 9 cubic feet which allows a sufficient margin of safety. This enables beams to be extracted cheaply. Payment is made per sleeper irrespective of size. The daily rate of roping is about 300 sleepers and the economical speed for each load, 1,000 feet per minute.

24. The timber is carried from the various saw-pits and stacked within a 50 feet radius of the top terminal of the span. Each stack is counted and the timber brought on to Form No. 7 (Rope-way Depots). The counted stacks are then made over to the rope-way contractor who ropes them down to the launching depot. By making this count it is possible to check breakages and damage by the roping contractor. He employs his own masons who carry out running repairs.

25. Each new rope-way must be given a number and have a history sheet started for it. The number can easily be stamped on a metal disk and secured to the rope. A careful record should be kept of the rope's movements from forest to forest, and at the end of each working season details of timber roped over it must be entered up in
the history sheet. All this will materially help in the ultimate calculation of depreciation costs and also assist the Divisional Forest Officer when he has to write off useless ropes. Written off ropes should be cut into 100 feet lengths and used for fencing or on roads and bridges. It is sheer vandalism to throw them into the river.

Slides.

26. The only form of slide of any importance is the wet slide or flume which is used for extracting timber from nullahs, the nature of which does not permit floating by 'Telescopic' slides.

27. The slide is made from 10 or 12 feet sleepers and bairdes, and it is generally unnecessary to cut special length timber for its construction. Diagram 15 shows the component parts of a wet slide:

Diagram No. 15.

The head of the trestle A, commonly called a Sikangi, consists of a rough round log of any timber about 2½ to 3½ feet long and 12" to 15" in diameter. The log is axed out to the size required which depends on the maximum size of scantlings to be exploited. It is now usual to cut the bed for the scantlings which are to form the floor of the slide, 2½ to 3½ inches lower than the sides. This does away with the need for broad sleepers for the sides and allows ordinary 10"x8" sleepers to be used without any sacrifice in depth. If the slide is only to be used for a year
the history sheet. All this will materially help in the ultimate calculation of depreciation costs and also assist the Divisional Forest Officer when he has to write off useless ropes. Written off ropes should be cut into 100 foot lengths and used for fencing or on roads and bridges. It is sheer vandalism to throw them into the river.

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![Diagram No. 18](image)

The head of the trestle A, commonly called a Sikong, consists of a rough round log of any timber about 2½ to 3½ feet long and 12½ to 15½ in diameter. The log is axed out to the size required which depends on the maximum size of scantling to be exploited. It is now usual to cut the bed for the scantlings which are to form the floor of the slide, 2 to 3 inches lower than the sides. This does away with the need for broad sleepers for the sides and allows ordinary 10"X5" sleepers to be used without any sacrifice in depth. If the slide is only to be used for a year
Once the alignment leaves the hillside, the cradle has to be supported on a trestle as shown in Diagram 16. The legs are rough poles of any wood about 3" in diameter at the upper end, let into the bottom of the cradle and splayed out so as to give rigidity. The scantlings are then fitted into the cradle. Normally, the ends of two successive sections meet, in the centre of the culvert, but where the legs of the trestle are very long, so that the trough is raised high above the ground, or where the slide crosses a stream, the scantlings composing the slide are made to "break joints": the bottom scantlings meeting over each main trestle and the sides over intermediate trestles.

At curves the outer edge of the trough is laid higher than the inner edge, so as to diminish the force with which the descending sleeper strikes the outer edge. Further strength is obtained by using 'dog spikes' and fixing them as shown in Diagram 16.

Diagram No. 16

Finally, each section is braced with wedges and the joints of the slide are caulked with moss, which is rammed into the crevices with a thin spatula-shaped piece of wood.

26. The first two or three sections at the head of the slide are laid almost dead level, in order to allow the water to enter the slides and the sleeper to be dispatched slowly. The length of an uninterrupted section of slide depends on the head of water. If the water-supply is insufficient, the slide should be in lengths of a quarter of a mile with deep pools in between. If, on a long length, water is available at a point below the head of the slide, it should be tapped and brought to the slide to act as a feeder. During launching, men with boat hooks are stationed at the pools and they pass the sleeper on to the next section.
must always enter the slide on their broad surface. On curve it is an advantage to have a sentry with a red flag or whistle who, in the event of a jam, can have the supply of sleepers cut off till the jam has been removed. To go on launching into the jam is merely trying to smash up the slide. Only one scouting at a time must enter the slide.

29. The force at which a scounting travels is much affected by the quantity of water in the slide; it descends faster than the water which in steep places is thrown out before it, so that, if the quantity of water be increased the force at which the scounting descends is proportionately reduced.

30. The gradients of these slides vary from dead Graduats. level to 40 in 160. The latter slope can only be used for very short distances and must be preceded and followed by dead level stretches.

31. Excluding the cost of sawing and carriage, which is the same for all species, the cost of building the slide should very rarely exceed Rs. 3 per running yard. In nullahs which have been worked in recent years the cost of construction has been about 2-3-0 per running yard.

FLOATING.

32. There are two types of floating, (a) slide nullah, General. (b) main river and as the two methods are totally different, each one requires expert labour.

33. The notable nullahs are those which have a moderate fall, but with plenty of water, and the method of extracting timber is by what is commonly called 'tapering chutes'. Launching takes place in the usual manner and the scoulings are built up into chutes of varying lengths, but always ending where a deep pool exists or can be made artificially, by damming up the sides and mouth with sleepers, brushwood and grass. When this length of chute is complete water runs over it, and more scoulings are passed down for the construction of the next chute and so on, till all timber has been launched. The general construction is that of a V shaped flume. There are one or two points which must be remembered. The pools must be deep and free from boulders: Floating contractors are
not going to build more chutes than they can avoid, but if a better pool to the existing one can be formed lower down, they must be made to add more chutes. The end of the chute must not be too high otherwise the sculling drops and hits the bottom. This can always be remedied by lowering the last section of chute so that the sleeper slides off into the water. Launching is usually done in August in these nullahs and not more than 2,000 logs a day should be given to the contractor. Floods are always likely to occur and the less timber there is in the nullah the less loss and damage can take place. Under no circumstances should the contractor be allowed to launch all the timber at once. They are very fond of doing this so that they can get rid of some of their unskilled labour.

**River Flooding**

34. This type of floating is very simple and consists of keeping the river free of jams and sweeping the river from the tail end of the “gall”, in order to leave no timber behind. Two parties form this sweeping party, one on each bank and they work downstream together. The men at the head are responsible for clearing the front of the “gall” and they must promptly break up a jam before more timber piles up on it. Terms and Directives (skilful men) re-launch timber marooned in midstream and also break up jams which cannot be dealt with from the banks. The work is simple and supervision is required to see that no scullings are left behind which could have been taken down.

**Launching Procedure**

35. Before launching starts all the depots must be checked with the launching lists by the Divisional Forest Officer or a Gazetted Assistant. The timber is then handed over to the contractor who signs the original launching lists. These lists are sent to the Divisional office and the timber is struck off Form Y as “launched”. The timber is laced with spars according to the launching orders of the division and thrown into the river. A sculling must never be thrown side ways and must always be launched “end on”. If the stack is some way from the river or the ground very rocky, the contractor must be made to build “slip ways” with the ends well over the water. Stacks should not be made too high but if the space available does not permit of small stacks, an earth pit should be dug near the stack and filled with brushwood in order to stop the ends splitting.
Chill timber does not float for long, and experience has shown that the percentage of loss from launching can be reduced by heavily terracing the side for about 9 inches. All timber of any species which begins to sink must be retrieved and placed above flood level. These stantings are usually re-launched in the following year. Spruce with red heart should season in the forest for a year before launching.

Log Works.

26. Log Working is not possible at present, but a general brief description is given here which may be useful in the event of necessity.

The tree is marked into logs, by the official in charge of the work, directly it is felled, and the measurements entered in a register. The logs are measured off from the butt end of the tree, cut throughout being taken to cut the logs of the tree, the rolls, throughout being taken to cut the logs of the tree, the rolls, throughout being taken to cut the rolls of the tree, the rolls, throughout being taken to cut the rolls of the tree, the rolls, throughout being taken to cut the rolls of the tree.

Much tapered trees cannot yield long logs and preference in length should be given to the butt logs. All logging, of course, must be done with a cross-cut saw and never with an axe. The longer the log the greater the price per cubic foot realized at the sale depot.

But the length of the log which can be extracted is limited—

(a) by the breadth of the rolling road which it is possible to construct at reasonable cost. Ordinarily a rolling road of 12 feet breadth can take logs up to a maximum length of 14 feet;

(b) by the state of the bed of the stream down which logs have to be floated. Ordinarily the length should not be greater than 15 feet;

(c) by the diameter of the log. But lengths of very large trees cannot be handled, any trees of more than 12 feet girth. Such girths may be of a minimum length of 7 feet.

After logging the trees the logs are worked down by rolling and by the use of wooden unders, or pears, until they reach a projected way, such as a rolling road, an earth slide or a dry wooden slide, down which they are passed to the bank of the river or other destination.

27. The rolling road is employed when the slope of rolling roads the hill is moderate and is sometimes constructed round the hill immediately below the forest, so that the logs may
be worked down to it from where they lie and they may then be rolled along it to the site of the mill or the head of a slide. It is also used in places where the route of the log on their way to the river or mill follows the bank of a river or the top of a precipice.

38. The road which is from 14 to 16 feet wide has a fall of not more than 10°. It is commenced by laying a row of large stones, as at (A) in Diagram 19, and above them rough logs of wood of various kinds or brushwood, obtained by the clearance of the line of road through the forest. It has been found that logs or brushwood are far preferable to stones for this purpose, as they are better able to stand the shock of the rolling timber. A coping (c) of rough stone is added at the outer edge of the roadway, and earth from the cutting is thrown down so as to give a horizontal cross section. On this poles (P.P.) are laid like rails on a rail road and down them the logs are slowly rolled, a few feet at a time, by means of wooden levers. Should the route lie across a small river or a hollow, the latter is either entirely filled up with logs, brushwood and stones, or bridged by a rough structure of logs with poles laid across them to form the roadway.
39. Whenever there is danger of a side rolling over the side of a rolling road into the river or over a precipice, the outside coping should be raised so as to give the rolling road a cant towards the inside or hill-side.

40. Cutting out the surface for a rolling road is always expensive and the cheaper method of walling and filling is sometimes employed. When a rolling road is to be used for only a year or two, a very cheap form of construction is to replace extensive walling and filling by four to eight posts on them and cover the top with a layer of brushwood and finally, earth. The poles should not be less than 3 feet in girth and must be securely fastened to the posts; the other end being buried in the hill-side.

Diagram No. 20

41. An earth slide is a natural hollow or drainage channel improved so that logs can be worked down it endwise by the aid of hoists. This method is apt to do considerable damage to the hill-side, especially in wet weather, and caution is necessary in working it. The fall should not exceed 25, otherwise logs get out of control; check walls are erected at intervals if there is possibility of this happening.

42. At a selected point on the earth slide a terrace, check wall, which may be from 90 feet to 70 feet long and 15 feet to
30 feet wide, is cut out of the hill-side. On its outer edge a row of logs AA in Diagram 21 of some 15 feet in length is planted perpendicularly to the direction of the slide, the logs being 6 to 8 feet apart, and having about one-third of their length buried. Behind them is erected a roughly constructed wood and stone wall from 10 to 20 feet wide at the top and about 6 to 10 feet high on the inner side. The wall rests on a foundation of solid earth cut out to receive it. Sometimes the outer face of the wall is supported by a second row of logs, the space between them being filled up with rough poles and other pieces of wood so as to hold the stones firmly and to prevent them being displaced by the shock of the falling logs. If the floor of the terrace be hard, it is usually sunk to a depth of 4 to 5 feet and the hollow thus formed (B) is filled with loose soil or brush-wood so as to check the fall of the logs and thus arrest them or, at any rate, to moderate the force with which they strike the wall. The logs are then moved by levers to the head of the next section of earth slide. On very steep slopes where check walls are required at short intervals it is not always possible to find places at which their foundations can be laid. In such cases a partial check is afforded by simply driving in a row of iron jumpers into the ground, to support a line of logs laid horizontally against them. These, checks, being much lower than
A check wall, must obviously be, placed nearer together than would be necessary, if ordinary check walls were employed.

43. This form of log slide is usually employed when the route of the logs lies across the hill slopes, or in localities where the ground is either very rocky and difficult to clear for an earth slide, or where it crosses over, or at the edge of cultivated fields. If composed, in sections, of 5 logs or tree tops (A, A, B, B, C) as in Diagram 22 so disposed as to form a roughly made trough. The two larger pieces (A, A) lying on the outsides are about 14 feet in girth, the inner logs or poles, being proportionately smaller.

The ends of these timbers rest on a, roughly made round sleeper (S) to which they are pinned down by a spike of hard wood (K, K). The tendency of the timbers to slip forward when the slide is in use is further checked by their being hollowed out below, so that they hook themselves on to the sleeper. Diagram 23 shows this and also the method of using the spike. A sufficient gradient must be given so that the logs travel easily; this will be

![Diagram No. 22](image-url)
64. When the logs reach the launching point, they are numbered consecutively and the Government property mark engraved on them, at both ends and opposite to each other.

Diagram No. 34.

The official in charge re-checks the logs and completes his register, which should now show the compartment No.; the number of the log; the species, length and mid-girth under bark. The cubical contents are entered in by the Range Officer. The Divisional Forest Officer, or other Gazetted Officer, usually checks 10 per cent of the logs prior to launching and, unless a special log "shall" be floated these logs, once launched, are left to get down to the depot alone. They should not be launched later than the 15th July. The best time to launch is in the winter because the rising water in the spring and summer carries the logs down a considerable distance. While launching great care must be taken to see that before the first log is removed the next one has been "scotched" up properly. Failure to do this is positively dangerous.

Miscellaneous

Care of Saws: 65. Cross cut saws are expensive things and if not looked after and sharpened properly, it takes a very short time to render them useless.
46. The exaggerated Diagram 25 shows in the form of the sketch the teeth of a cross cut saw. A A are the two cutting teeth and B B are the "rakers". The two points of the cutting teeth are about slightly in opposite directions and actually cut the wood, while the "rakers" serve to remove the kerf from the cut. An universal error committed by almost all saw filers in the hills, is to make all the teeth of the same height. This is quite wrong. The "rakers" must be 1/16th of an inch shorter than the cutting teeth. Saw filers can usually get the "set" of the cutting teeth right because they have a set which cannot go wrong. Once a "raker" becomes a cutting tooth, the saw refuses to work properly and the "raker" eventually snaps. The Divisional Forest Officer should periodically inspect the saw filers' work by picking out, at random, one or two sharpened saws and placing a 2' rule, or other, flat articles, on top of two pairs of cutting teeth. If the saw has been sharpened properly, the "raker" will be clean.

47. After shutting down work for the day the saw should be wiped over with a rag dipped in kerosene oil so as to remove resin. Saws must never be left on the ground because they will lose their shape and eventually get broken by a rolling log. When not in use the saw must be suspended from the branch of a tree.

48. All exploitation equipment and the best type of saws (given below) can be arranged through Controller of Stores, Punjab.
49. The size required depends solely on the diameter of the tree to be logged or felled, but it should be remembered that a clear pull of under 18 inches is very inconvenient and results in waste of time.

50. There is a difference between hard wood saws and soft wood saws and the proper type saw should always be insisted on.

51. Very great losses occur owing to the degrade of sleepers during the process of seasoning, chiefly due to cracked ends. Much of this degrade takes place before the sleepers arrive at the 'safe depot, and for this reason precautions against this loss must be taken from the moment the sleepers are sawn. The stacks should be made in open crib fashion so that air can circulate, the ends must not be exposed to the sun nor the sleepers left lying about unnecessarily exposed to the weather. At the launching depot similar precautions should be
taken. Wherever possible the stacks should be made in the shade; elsewhere they should be covered with earth. The stacks should be close together so that the ends are protected and it may be advantageous to tar the ends of all sleepers as is already the standard procedure for chink. On arrival in depot the standard packing for sleepers to be offered to the Railway is the 1 to 9 system. The stacks should be arranged so that the prevailing wind blows through them; the ends of the sleepers should be close together but not touching. The outside stacks of the block exposed to the south and west should be so arranged that the length of the sleeper and not the ends faces the sun. The top and the outside ends of the block of stacks should, as far as possible, be protected from the sun. Spreading for passing should only be done immediately before passing. If any signs of fungus is present this should be removed. A saprophytic fungus known as Schizophyllum commune, Fr. is sometimes found on chink and fir sleepers. This has been pronounced by the Forest Research Institute to be of no consequence, but the Railway Passing Officers object to it. In short, from the sawing of the sleeper up to its final passing to the Railway, every possible precaution should be taken to prevent too rapid or too unequal drying of the timber which is responsible for cracked ends and the consequent rejection of the sleeper.
TECHNICAL ORDER NO. 10
CONSTRUCTION AND REPAIR OF BUILDINGS

Earth-work.

1. The excavation of foundations. Trenches must be in exact accordance with the drawings. The trenches must be taken out to the exact width of the lowest step of the footings. Care must be taken that the bottom of the trenches are truly level in all directions, that any spillings ordered are strictly attended to, and that sides are kept plumb where the soil admits of it.

The bottom of all trenches must be well watered and rammed. Care being taken that too much water is not used. Soft and defective places are to be brought to the notice of the Divisional Forest Officer or Range Officer in charge, and holes are to be filled with sand or concrete.

On the completion of the excavation the work must be measured up and passed by the Range Officer, and the measurement agreed to by the contractor. A report must be made to the Divisional Forest Officer, who will, if possible, inspect the foundations before building is commenced.

The ground in the immediate neighbourhood will be cleared of all jungle and all hollows filled. Trees will not be cut without the orders of the Divisional Forest Officer.

On the completion of the building the ground all round to a distance of 30 feet is to be cleared of all debris, and be given a slope of 1 in 40 outwards. The foregoing does not apply to buildings in the hills.

2. Earth filling.—As soon as a building has reached plinth level, the space between the masonry and the side of the trenches is to be cleared of all debris and filled with earth laid in 6 inch layers, watered and rammed.

All earth filling should be carried out in successive horizontal layers well consolidated, water being used if necessary.

Mortars


5. Mixing.—The quantity of water to be used must be decided on the spot, but much water must not be used. First, of all the cement and sand must be thoroughly mixed together on a clean platform in a dry state, until the colour of the cement is evenly distributed throughout the sand. The smallest amount of water should be used which will give a sufficiently plastic mixture for the work in hand.

Small quantities should be mixed sufficient for about 15–20 minutes' work.

6. Laying.—The mortar having been mixed should be applied at once, trowel worked quickly into place, smoothed over, and not touched again. In the plains during the hot weather stones and bricks to be set in cement mortar must be well soaked in water.

The following proportions by measure are generally suitable:

(i) Masonry not requiring great strength

Cement 1, Sand 4

(ii) Strong masonry

1, 3

(iii) Repairing surface defects in concrete

Cement, pointing
end grouting

1, 2

(iv) Waterproof washes

1, Nil

Precautions:

(i) Portland cement improves by age, if kept from moisture.

(ii) The longer Portland cement is in setting the stronger will it be.

(iii) The cleaner and sharper the sand the greater the strength.

(iv) The less water used in mixing up the cement the better.
7. Lime mortar.—Lime stone or lime kankar should be burned to form lime, in such kilns and with such fuel as is locally found. Wood and charcoal are both very good. Departmental manufacture is preferable; but if lime is supplied by a contractor its manufacture should be supervised; in either case the lime must be tested periodically.

8. Storage of lime.—As a rule lime should be used within 24 days of its manufacture. If it is to be stored it must be placed on boards raised a few inches above the ground, and must be kept dry. Fat lime should be stored in an enclosed space in a large heap, and air excluded in every possible way, or it may be kept in tanks and covered with water.

9. Ingredients.—Lime, surki, if necessary, sand or clinders and water, the proportions depending on the work in hand.

10. Mixing.—The mortar should be mixed (by measure) on a clean platform close to the mill. For measuring wooden boxes 12"x12"x12" may be used.

Where surki or clinders are used with fat lime, the lime and surki, must be thoroughly mixed dry in the first instance.

The ingredients should be turned over dry on the platform, placed in the mill and water added as required, care being taken that too much water is not used. The mortar should be ground for 4 hours, being stirred up continually during the process.

The blow of lime can only be prevented by fine screening and keeping wet for at least 24 hours before it is used.

Lime mortar should be kept ready for use in troughs and in hot weather be protected with mats. Mortar which has once set, or which has lain for more than 24 hours on the ground, is unfit for any use. When using kankar lime for plastering, however, it is better to leave it for some time to sour.
11. Laying.—With hydraulic lime mortar, the bricks and stones should be well soaked in water.

The following proportions (by measure) are usually suitable:

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<thead>
<tr>
<th></th>
<th>Mortar for Masonry</th>
<th>Mortar for Concrete</th>
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<tr>
<td></td>
<td>Lime</td>
<td>Sand</td>
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<tr>
<td>Hydraulic lime</td>
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<td>Mod. Hydraulic, flint.</td>
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<tr>
<td>Pat. lime</td>
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</tbody>
</table>

Precautions. In using hydraulic lime, the necessity of thoroughly soaking the bricks or stones in water before laying them in mortar should be carefully observed. If the moisture is suddenly drawn off any hydraulic mortar it will not harden. Dry bricks and most stones absorb a large quantity of water and if laid dry take it up from the mortar between them which crumbles into powder. In the case of compact stones it is sufficient to water their surfaces just before use, but porous materials such as sand stone and bricks should be allowed to soak in water for some hours before use.

Lime mortar should be used as stiff as it can be spread. All joints should be well filled.

The work should be kept well wetted for a week or ten days after it has been laid, to prevent the rapid drying of the mortar especially in hot weather.
12. Mud Mortar. Mud mortar should be prepared from stiff clay, to be approved of by the Range Officer, which is broken up into fine powder and freed from grass, stones, etc. The clay should be mixed with clean water on a clean platform and worked up to the consistency of clay for brick-making.

Before use, the mud mortar should be moistened with water to the required consistency.

CONCRETE

13. Portland Cement Concrete.

14. Ingredients. Portland cement, sand, gravel or broken stone and water. The proportions depending on the nature of the work in hand and the ingredients.

15. Consistencies. The consistency of the mixture depends on the quantity of water used.

16. Dry consistency. Water 40 to 50 gallons per 100 c.f.t., similar to damp earth, must not be laid in more than 6" layers and well rammed. Should be used only in mass foundations where great strength is required. Being porous it is entirely unsuitable for water-tight work.

17. Medium or Quick setting consistency. Water approximately 100 gallons per 100 c. ft. Jelly-like, shakes on rammimg. Should be used for all ordinary mass concrete.

18. Wet or Mushy consistency. Water approximately 150 gallons per 100 c. ft. Will hold its shape in a pile, and will flow sluggishly in a trough. Should be used for all reinforced concrete and water-tight structures.

19. Measuring. Cement should be measured by weight (90 lbs.=1 c.f.t.) the sand and aggregate should be measured separately in bottom less boxes 12"x12"x12" on clean platforms.

A single batch should not exceed more than 15 c. ft. of coarse rubble.

20. Hand mixing. The coarse aggregate should be kept in water for 4 hours before using. The sand measured and levelled on the clean platform, the cement measured on top of the sand. The dry sand and cement will be turned over 3 or 4 times until the colour is uniform. The mixture
of sand and cement will be placed on top of the coarse aggregate. The measured quantity of water will be gradually added with Rose watering cans (never splash water on by hand) and the mixture turned until properly mixed. Six men are required to do the turning, and one supplies the water. Thorough mixing will give better plasticity. Mixing must be so timed that the concrete will be placed in position within half-an-hour of adding water.

21. Placing. After mixing, the concrete must be handled rapidly, and in as small masses as possible placed in the final deposit. Never throw concrete into foundations, etc., if it must be carefully placed into position. When deposited, the concrete should be thoroughly compacted until all the ingredients have settled and the surplus water forced to the surface. Excessive tamping should be avoided and should be completed within 20 minutes of the addition of the water in mixing.

When the placing of concrete is suspended, any necessary grooves for joining future work must be made before the concrete has set. When work is resumed, the concrete previously placed must be thoroughly cleaned, roughened, watered and then stilled with mortar consisting of 1 part cement to 1 part sand.

22. Freezing. On no account must concrete be allowed to freeze, but must be protected with covering or grass.

23. Proportions. The following proportions are usually suitable:

<table>
<thead>
<tr>
<th>Kind of Mixture</th>
<th>Sand</th>
<th>Aggregate</th>
<th>Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ready mixture for Piers, and other structural parts or those requiring water-resistance above ground.</td>
<td>1 ½</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Standard mixture for reinforced floor slabs, water tanks, and other structures below ground.</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Medium mixture for ordinary machine foundations, building walls, building walls, office floor, paths.</td>
<td>2 ½</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Lean mixture for mass concrete in many walls for large foundations, and for backing stone masonry.</td>
<td>3</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>
24. **Mud Concrete.** Is prepared from stiff clay in a similar manner as for mud mortar, to which is added brick ballast made from well burnt or over-burnt brickbats to 2 inch maximum gauge, and well graded as far as possible to secure a minimum of voids.

25. **Mixing.** The mortar and brick ballast should be mixed together in suitable proportions, usually 1 to 2 or 3 on clean platforms, and laid in 6 inch layers and rammed to the extent necessary to consolidate the mixture, only, similar to lime concrete. Care must be taken not to use too much water.

**BRICK-WORK**

26. **General.** All walls of buildings should be carried up as far as possible at the same level throughout, and no step left temporarily during construction should ever exceed ten courses. When steps are left, the junction must be backed back in regular steps of one course each. Cross walls and butterresses should be always built simultaneously with the main walls and must never be jogged in afterwards.

All iron work, wood blocks, pipes, and outlets for water should as far as possible be built in as the work proceeds. Whenever timbers are to be embedded in the walls they must be either completely embedded so that no air space exists next to the wood, or an air space of 2" must be left on all sides and at the top. In the planes all timber placed in buildings must be treated with Creosote or coal tarred.

Double rows of scaffolding poles should be used, and ordinarily no holes are to be left in walls to support the scaffolding. Where necessary Headers (not stretchers) may be used for the scaffolding. The height of the scaffolding must be kept within a few feet of the top of the finished work.

The joining of new work to old requires a good deal of care, as the new work is bound to settle and crack. A good method is to cut a vertical groove in the old masonry and to
build the new masonry with a tongue fitted into the groove, this method can be used with first class pointed work or where sundried masonry is joined to burnt brick-work.

Brick must be used when it is necessary to make a closure, that is, to finish the end or a corner of a wall, or side of an opening, and even then no piece smaller than half a brick should be used.

The beds of the courses must be perpendicular to the direction of the pressure which they have to bear and bricks in each course must break joints with those of the courses above and below it by overlapping to the extent of from one-quarter to one-half of the length of a brick.

27. Materials and bonds. First class bricks will consist of stock made bricks of uniform shape, size and colour, and thoroughly well burnt. Each brick must be free from defects, quite straight and rectangular, ring clearly when struck, and be perfectly sound in all respects. No bricks should absorb more than 1/6th of its weight when soaked. The usual size of a brick is 9"×4½"×2½".

28. Second class bricks. Will only differ from 1st class in that the colour and shape is not so good or uniform.

29. Third class bricks. May include burnt and distorted bricks but never under burnt or pille bricks. Under this class come Kumhar or country bricks, which must be well burnt and sound, and should not be smaller than 3½"×3½"×1¾".

30. Sundried bricks. May be made from stiff clay thoroughly worked up, exactly in the same way as for 1st class bricks. For good work they should be sand moulded, for inferior work stop moulding will do.

31. Mortar. Burnt bricks may be laid in cement, lime, or mud mortar. Sundried bricks will be laid in mud.
32. Bond. All bricks will be laid in English bond. No half bricks or hats may be used except where necessary to complete the bond.

Each course must be perfectly level, and every brick must be well bedded in the mortar, and all joints well flushed up. The faces of all walls must be perfectly plumbed.

Bricks must be carefully handled by coolies and carmen, otherwise the edges and corners will be damaged.

33. Backwork in lime. Mortar as previously described.

34. Standards. 1st, 2nd and 3rd class brick work are the same as regards specification, except as noted below.

35. Laying. No broken cracked or underburnt bricks may be used. In walls that are not plastered bricks of the most uniform colour and shape must be selected for the face work. For 1st and 2nd class work all bricks must be soaked for two hours before use. For 3rd class brick-work the bricks may be dipped into a tub of water (not soaked) before use. Special care must be taken in 3rd class brick-work on account of the difficulties caused by the disproportionate and irregular shape of the bricks. In walls two bricks thick, the central longitudinal joint in each header course will often be necessary very wide for the above reason. This should be minimised by selecting the longest bricks for the header courses. Particular care should be taken that vertical joints on faces break joint properly.

36. Joints. Are to be of uniform thickness, not exceeding 1/4", 1/2" and 3/4" for 1st, 2nd and 3rd class brick-work, respectively. In 1st class brick work the vertical joints must be quite symmetrical and truly plumbed.

The joints in floors which are to be plastered or pointed should be backed out while the mortar is green, i.e., not later than 24 hours after the work is done. Where faces are not going to be plastered, or pointed, the joints must be struck flush with the edges of the bricks and smoothed flat as the work proceeds.
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the curvature of the arch. The centerings are to be struck within 24 hours of the completion of the arch; in the case of semi-circular, semi-elliptical, or pointed arches, they should not be struck until the adjacent brickwork has reached 2/3 of the height of the arch. The centering of arches of over 7' span should be made on double wedges, to admit of easing the centering before striking it.

42. Keystones. The keystone must be driven firmly into position with a wooden mallet.

43. Watering. The completed arch should be kept well watered for 7 days.

44. External joints. Should be struck flat and smooth as the work is done, but if it is to be covered by plaster the joints should be raised out within 24 hours of the completion of the work. The joints should be carefully kept to the required thickness, any bad work done in the interior will be immediately disclosed by the large joints in the extrados.

45. Sundried brickwork. General. The general specification for sundried brickwork in clay mortar will be similar to that for brickwork in lime, except that the bricks are to be the best unburnt sand or stop moulded bricks procurable. The bricks are not to be wetted before use.

46. Plastering. After completion, sundried brick walls will be plastered and leaped.

Sundried bricks must be protected from the weather until dry.

47. Arches, etc. Arches, doors and window jams, sills, etc, in sundried brick buildings may be made of burnt bricks in clay or lime.

48. Kacha, pakka brick-work. General. In kacha pakka brickwork the exterior faces will be faced with burnt brick in mud, and cement pointed.

49. Plinth pillars, arches, etc. The plinths and top 2 or 3 courses of the wall should be burnt brick laid in mud or lime, and where header beams or braces rest on walls burnt brick pillars are to be built up in the wall from the foundations. Arches, jams, etc., should be built of burnt brick in mud.
69. Limitations. Kacha pakka brick-work is as a rule only adopted for inferior buildings in a dry climate. Care must be taken as previously explained to see that the sundried and burnt bricks are the same size, and that joints are of the same thickness, and that sundried and burnt brick-work are properly bonded together in the work. The sundried bricks must be absolutely dry. The height of wall of this type should never exceed 18 feet.

51. Drip course. The bricks will be laid on edge. Each brick will be cut with a chamfer 1/2" deep on the outer corner of the upper edge and a threading 1/4" deep on the lower.

MASONRY

(1) Stone Masonry.

32. General Rules. The general rules for masonry work given for brick-work apply equally to stone masonry.

33. Mortar. Stone masonry may be laid in cement, lime or mud according to the class of work.

34. Stone masonry in lime. Will be rubble or as specified.

35. Mortar. The same as for brick-work in lime.

56. Watering. Stone masonry in lime will be kept wet after laying as specified for brick-work. The stones will be soaked for two hours, before laying.

57. Course Rubble Masonry. It consists of a series of horizontal courses varying from 6" to 12" in thickness, each of which is correctly leveled before another course is built upon it. The side joints are not necessarily vertical, the thickness of courses varies, but the thickest course should always be placed at the bottom and the thinner courses high up in the work. Each course is usually the thickness of the stone, but occasionally the whole or portion of a course is made with a depth of two or more stones. All headers must, however, be of one stone thickness. Course rubble masonry is commonly used for all kinds of large and important buildings. If the material is good and the work carefully carried out, it is suitable for every kind of work except Cornices, Coping, arches and ornamental works.
58. Stone. The hardest stone procurable should be used. All stones must have a clean section; discoloured, discoloured, cracked ones or stones showing signs of decay, must be rejected. Stones with round surfaces are not to be used.

59. Construction. Coursed Rubble will be laid in courses varying in height as may be most convenient and economical according to the nature of the stone procured from the quarry. No courses may be less than 6" and more than 12" in thickness, and no course may be of a greater depth than the one below it.

60. Joints. Will be 4" thick.

As a rule no stone in the face of a wall should be less than 4 cubic feet in size, and in walls over 14 feet thick not more than half the stones should be less than 4 cubic feet.

No face stone may be narrower and shorter than its depth, its length falling into the wall must be at least one and a half times its height, and 1/3rd of the face shapes must fall in at least twice their height.

The bed of each stone must be horizontal, and it must be in line dressed, true and square for at least 3" back from its face. The vertical joint will be dressed back not less than 2". The vertical joint must not be at right angles to the face of the wall, but it must be truly vertical, and at an angle of not less than 30 degrees to the face of the wall.

61. Through Stones. Or headers will fulfill all the conditions of face stones, except as regards their length which must not be less than 18 inches. They should be inserted every 3 feet apart in the clear in every course and must run right through the wall within the wall is not more than 2 feet thick, in thicker walls a line of two or more headers must be laid from face to back, overlapping each other by at least 6". Through stones must not be in the same vertical plane in successive courses, they must be marked to facilitate checking.

62. Hearling. The hearling, or interior filling between the front and back face stones, will consist of rubble stones, not less than 6" in size, carefully laid, hammered
down and solidly bedded down in mortar, chips of stones being wedged in whenever necessary so as to avoid thick beds, or joints of mortar, care being taken that a dry work or hollow spaces are left in the masonry. The heaering should be laid nearly level with each course except that at about 3 feet intervals vertical planes projecting 6" to 9" will be firmly embedded to form a bond between the successive courses. The heaering must not be brought to the same level as the back and front stones by the use of chips, the use of the latter being entirely restricted to wedges in the heaering.

Random squared coursed Rubble Masonry.
Random course Rubble Masonry...
Random Rubble Masonry.

63. Stone Masonry in Arches. An elevation of the arch should be drawn out on the ground and vousoirs of different widths according to the stone to be used are to be marked. Light tempels should then be cut out and stones dressed according to the tempels.

The arch stones should be fitted together on the ground.

The stones must be specially selected, they should give a clear metallic ring when struck with a chip of the same stone.

64. Through Stones. The arches in walls, the key stones, the two outside stones, and a due proportion of the stones, must be through stones. In 18 inch walls a suitable proportion is every third stone in the face.

65. General. The front and back faces must be square to the planes of the side faces. The height of each stone must be equal to the thickness of the arch up to 10", above this two stones may be used, but no stone may be less than 6" high, and no stone may overlie a circumferential joint by less than half the extrados width. The intrados of any stone must not be less than 3" and in each stone the exposed face of the intrados must be rectangular.
All stones put in arches must have their ends inside the wall squarely dressed. The joints must break joint with each other. No small stones on any account should be allowed.

69. Centering. Should be passed by the Range Officer before the archway is commenced. The centering must be wedged into position so that it can be eased as soon as the arch has been turned and the header filled in. The centering must not be removed until the mortar has set.

**Dry Rubble Masonry.**

67. General. All classes of rubble masonry walling can be built dry. This class of wall is most suitable for breast and retaining walls.

68. Through Stones. Through bonds front to back, consisting of a single stone or of several stones put end to end must be given in every course at intervals of 5 feet. Single through stones should always be used when available.

The limit of height of stone walls depends on the quality of stone and the space available at the base. High walls should be strengthened with bands of stone in line at every 4 feet in height.

69. Filling. The filling immediately behind a dry stone wall should consist of stone refuse and chips. Earth should not be used unless unavoidable. Suitable arrangements for drainage must be made.

70. Dry rubble masonry with wooden binders. In the inner hills mortar is not available and buildings are erected with dry rubble walls strengthened with wooden binders.

The foundations are of concrete and stone masonry. Coursed rubble masonry walls of hammer dressed stones and specifications already described are built to a height of 2 or 3 feet and the first wooden binders are then laid horizontally and morticed together in pairs. On them are laid further courses of rubble masonry, and at vertical
intervals of 3 feet other wooden binders are laid. The walls should be raised progressively and binders laid at the same level in each course. It is wrong to lay the binders first and then fill in the intervening spaces with stones. The wooden binders should be of Deodar. Kail may be used only when no Deodar is available, and the kail binders must be well coal-tarred on all sides. All wood must be thoroughly seasoned before use.

The binders should be 6 inches in width and 4 to 6 inches in thickness, of sawn or axed timber. Sapwood should be avoided.

The thickness of the binders in one and the same course should be the same. The binders should when practicable run throughout the entire length of a wall. If they or more pieces have to be used to make up a length the end should be jointed by a simple scarf and wooden or iron nails. At corners the ends of the binders should be jointed in a similar manner. The front and back binders should be kept in position by means of wooden cross-tie pieces of suitable dimensions, fastened by dovetailed joints on to the binders at 4 to 6 feet intervals in the length of the wall, and about a foot away from the joint on either side of all the joints between any two pieces of binders.

71. Dhaiji walling. Dhaiji walling consists of rough light timber framework filled with small boulder or round stones in mud. The main frame for small buildings such as seed godowns, servants' quarters, etc., should be 4" x 4". For walls over 6 feet high and for larger buildings 5" x 5" posts are generally suitable.

The framework will be filled in with stone in mud and plastered both sides level with the posts, the wood being nicked to make the plaster adhere.

In high unprotected walls a rendering of lime plaster may be given on the outside.

POINTING, PLASTERING AND WHITEWASHING

1. Pointing.

72. Preparing walls. All joints are to be first raked out with a hook (not hammered) to a depth of ¼. In
new work the joints must be raked out before the mortar sets. In old work the wall must be thoroughly wetted first. After raking out the joints the surface to be pointed must be cleaned down and kept wet for two days before pointing is commenced. All dust must be brushed out of the joints after raking out old work. The raking out of joints and surface cleaning should be kept at least 4 feet ahead of the pointing.

Cement mortar only should be used composed of 1 part cement to 2 parts sand. The cement and sand to be mixed dry and only sufficient for 10 or 15 minutes' work to be made at a time.

73. Applying. The mortar will be placed in the joints, well pressed in, rendered smooth and flush with the surface of the wall, care being taken that it does not spread over the masonry.

The horizontal lines will be struck back with the trowel along the upper edge. The vertical joints should be struck semi-circular or V shaped by means of a round iron tool, \( \frac{1}{2} \)" in diameter. For interior walls which are not to be plastered, the joints should be finished flush as the work proceeds.

When rough stone masonry is pointed the mortar is struck off with a trowel and left, showing frankly such irregularities as are produced by the corresponding irregularities in line and surface of the stones themselves.

After pointing the work should be kept thoroughly wet for not less than 7 days.

II.—PLASTERING

74. Preparation of walls. Walls should be prepared as for pointing. Walls will be plastered with lime, cement or red plaster. The plaster may be applied in 1, 2 or 3 coats, but no single coat must exceed \( \frac{1}{4} \)" in thickness. On very rough walls a preliminary coat must be given to fill up the hollows, before the first coat is laid on.

Before work is started patches of plaster, \( 6" \times 6" \) should be put on at 10 apart to act as gauges by this means an even thickness is obtained. Cement plastering
must be done in squares or strips, cracks will appear if large surfaces are done.

Scraping walls which comprises removing white or colour wash and making good the surface of the plaster should only be done when the surface of the plaster becomes very rough, usually not less than 5 years.

Rags of gunny or husks of coconuts sawn in two should be used for scraping.

75. Lime plaster. Lime plaster must consist of lime mortar as specified previously. It should be ground fine until it contains no lumps or grit. Hot lime makes the best plaster as any unburned remains in hydraulic lime will cause blisters.

The addition of 10 lbs. of gum boiled in water to 100 cubic feet of mortar improves the plaster, also a small quantity of chopped hemp.

76. Superior lime plaster. Cement: Of one or more rough coats as necessary, floating coat, and seidling coat.

77. Ordinary Lime plaster. Consists of rough coat and floating coat. One coat floated will usually suffice in good brick-work for ordinary purposes.

78. Rough coat. The basis of lime plastering consists of one or more coats of rough coat. It should be laid on sufficiently thick to cover all projections of masonry by 4" of plaster. An average thickness of 1/2" will usually be sufficient to effect this in all classes of brick walls. 1" will usually be sufficient for stone masonry. No coat of plaster should be more than 1/2" thick in any part. If the wall is so uneven that the plaster must be thicker than 1" in order to cover all projections by 4", the plaster must be applied in two or more coats, each coat being not more than 1/2" thick. In the case of old walls being out of plumb the walls should not be brought to plumb with plaster.

The plaster will be applied with trowels and will be well pressed into the joints until the necessary thickness has been obtained. It will then be beaten with long thin laths until no impression is made on the surface.
Each coat must be allowed to set before the next is applied and the surface should be left rough and freckly scored with the edge of a trowel to give a key to the next coat.

79. Floating coat. The lime mortar on the surface of the floating coat must be ground specially fine and smooth, this can be done by rubbing between two stones.

The final surface, when it has become quite firm and before it has set, will be floated by means of a straight edge drawn backwards and forwards until it is quite smooth. The finished plaster must be watered for 3 or 4 days after it has been put on, in hot weather any wall exposed to the sun must be protected with mats.

III.—Cement Plastering.

80. Mortar. Portland cement plaster consists of fine cement mortar as specified for stiff consistency, one part cement to two parts sand is the normal suitable mixture. For watertight cement plaster the proportions are, 1 part cement to 1 part sand. Cement plaster should be kept wet for at least 7 days.

IV.—Mud Plastering.

81. Composition. Mud plaster is composed of stiff clay to which is added, if ordered, an equal bulk of chopped straw or pine needles. In certain cases it is necessary to add sand. The clay after being excavated should be spread out in the sun and powdered; the chopped straw or pine needles should then be added and thoroughly mixed in the dry state with plowhaws. Afterwards water should be added and the whole should be left to soak for 3 days. It should then be again mixed with plowhaws and water added until the consistency of stiff clay is obtained.

82. Application. The plaster should be spread evenly over the surface usually 1" thick on the roofs and 1½ to 2½" on the walls and floated with a straight edge until the surface is perfectly smooth. Any cracks that appear during drying must be filled in with liquid cowdung.

When the plaster has dried it will be leeped with a mixture of cowdung, clay and sand.
The l e e p i n g  i s  p r e p a r e d  a s  f o l l o w s :  T h e  c o w d u n g  i s  s t e e p e d  i n  w a t e r  t o  f r e e  i t  f r o m  g r a s s ,  e t c .  O n e  c u b i c  f o o t  o f  f i n e l y  p o w d e r e d  c l a y  i s  a d d e d  t o  e v e r y  c u b i c  f o o t  o f  c o w d u n g  a n d  t h e  w h o l e  w e l l  m i x e d  i n  a  t u b .

F o r  p l a s t e r i n g  t h e  i n s i d e  o f  c h a r n i n s  a  m i x t u r e  o f  t h r e e  p a r t s  c o w d u n g  t o  o n e  p a r t  l i n e  s h o u l d  b e  u s e d .

V.—W h i t e  W a s h i n g .

82. 'W h i t e w a s h . ' T h e  l i m e  o f  w h i t e w a s h  i s  u s u a l l y  t a n k a r  o r  s h e l l  l i n e ,  b r o u g h t  t o  t h e  s i t e  i n  a n  u n s t a c k e d  c o n d i t i o n .  I t  i s  t h e n  s t a c k e d  w i t h  a n  e x c e s s  a m o u n t  o f  w a t e r  a n d  a l l o w e d  t o  r e m a i n  u n d e r  w a t e r  f o r  2  d a y s .  T h e  m i x t u r e  o f  l i m e  a n d  w a t e r  i s  t h e n  d r a w n  o f f  a n d  p l a c e d  i n  a  t u b  a n d  c l e a r  w a t e r  i s  a d d e d  t o  b r i n g  t h e  m i x t u r e  t o  a  c o n s i s t e n c y  o f  t h i c k  c r e m e .  T h e  w a s h  s h o u l d  t h e n  b e  s t r a i n e d  t h r o u g h  a  c o u r s e  c l o t h  i n t o  a n o t h e r  t u b ;  t o  e a c h  t u b  f u l l  o f  w a s h  m u s t  b e  a d d e d  2  c h i t t a k s  o f  g u m  a n d  r i c e  w a t e r  o b t a i n e d  f r o m  2  l b s .  o f  r i c e .  T h e  i n g r e d i e n t s  a r e  p r e p a r e d  b y  h o l l i n g  t h e  r i c e  a n d  g u m ,  t h e n  s t r a i n i n g  t h r o u g h  a  s h e l e c l o t h .  T h e  w h o l e  i s  t h e n  s t i r r e d  t o g e t h e r  a n d  b o i l e d .

84. P r e p a r a t i o n  o f  t h e  s u r f a c e .  T h e  s u r f a c e  t o  b e  w h i t e w a s h e d  m u s t  b e  c l e a n  a n d  s m o o t h  b e f o r e  t h e  w h i t e w a s h  i s  a p p l i e d ,  a n d  b e  q u i t e  d r y .  A l l  g r e a t y  s p o l s  ( i f  a n y )  s h o u l d  b e  g i v e n  a  c o a t  o f  r i c e  w a t e r  a n d  s a u d  b e f o r e  t h e  a p p l i c a t i o n  o f  t h e  w h i t e w a s h .  I f  o l d  w h i t e w a s h e d  s u r f a c e s  a r e  d i s c o l o r e d  b y  s m o k e ,  i t  i s  a d v i s a b l e  t o  a p p l y  a w a s h  o f  a  m i x t u r e  o f  w o o d - s a t e s  a n d  w a t e r ,  b e f o r e  t h e  n e w  c o a t  o f  w h i t e w a s h  i s  a p p l i e d .  A n y  p a t c h e s  o f  n e w  p l a s t e r  s h o u l d  r e c e i v e  a n  e x t r a  c o a t  o f  w h i t e w a s h  b e f o r e  t h e  r e g u l a r  c o a t s  a r e  a p p l i e d ,  w h i t e w a s h  m u s t  n o t  b e  a p p l i e d  u n t i l  t h e  n e w  p a t c h e s  a r e  q u i t e  d r y .

85. A p p l i c a t i o n .  T h e  w a s h  s h o u l d  b e  p u t  o n  w i t h  a  c l e a n - b r u s h ,  e a c h  c o a t  c o n s i s t i n g  o f  o n e  v e r t i c a l  s t r o k e ,  f o l l o w e d  b y  o n e  h o r i z o n t a l  s t r o k e ,  e a c h  c o a t  m u s t  b e  a l l o w e d  t o  d r y  b e f o r e  t h e  n e x t  i s  a p p l i e d .

T h r e e  c o a t s  w i l l  b e  g i v e n  o n  n e w  w o r k ,  a n d  o n  s c r a p p e d  s u r f a c e s ,  t h e  o r d i n a r y  a n n u a l  w h i t e w a s h i n g  w i l l  c o n s i s t  o f  o n e  c o a t .  T h e  s u r f a c e  w h e n  c o m p l e t e d  m u s t  n o t  b e  p o w d e r y  o r  r e a d i l y  c o m e  o f f  o r  t h e  h a n d  w h e n  r u b b e d .
Flooring.

83. Plinth filling. The plinth filling - water-ground flooring should be watered and rammed in 6” layers until it is thoroughly consolidated and will not yield to a heavy blow with a rammer. The surface then should be brought to the level shown on the drawings. Inner floors must be perfectly level and verandah floors must be given an outward slope of 1 in 40. Any old bricks form an excellent filling, if properly rammed.

Brick and Tile Flooring.

87. Composition. The form of flooring consists of Ist class bricks or second, according to the class of building, laid in lime or mud, either flat or on edge or of tiles laid on 3” of lime concrete.

88. Laying bricks or tiles. The bricks or tiles must be soaked in water for 2 hours. They should be laid true and level either in parallel rows breaking joint or in herring bone bond, and all joints must be true and level.

The joints must not exceed 1/4” in thickness, the sides of the bricks being rubbed as necessary. The joints must be finished off flush and no mortar must be allowed to spread over the bricks or tiles. If they are to be pointed the joints should be not less than 1/8” thick, they should be raked out while the mortar is still damp and the floor pointed as specified for pointing.

The floor must be kept wet for 4 days after laying, and 8 days after cement pointing.

Earth Flooring.

89. Composition. The earth used must be a lean or a clay; sandy soil or ordinary mould are unsuitable. If earth is fresh and damp no water should be added, otherwise a little water is to be sprinkled on by hand. The less water used the better the floor will be.

90. Laying. The earth will be thoroughly consolidated in 6” layers until a very faint mark can be made with the heel of the boot. In the case of renewing the whole of the old earth must be dug up and removed before any new earth is put down.
Chimneys and Fireplaces.

91. These plans are attached herewith. It is not intended that this is the only shape of fireplace which will burn well, but it has been shown by experience to draw well, and to throw out heat, and may therefore be generally adopted.

The following points are to be observed:—

92. 1. Position of fireplace—

(i) It should not be in the corner of a room, for

(a) the corner is more useful for other purposes,

(b) the chimney will generally not pass through the centre of the roof in a pent-roofed building,

(c) the masonry takes up more room in the corner than in any other place,

(d) the fire does not throw out heat so well, and the heat has further to go to reach the diagonally opposite corner than it would have to reach the farthest part of the room if the fireplace were in one of the sides,

(ii) A fireplace should never be put in an outside wall if it can be placed elsewhere, as it is obviously economical to utilize the heat to warm another room and not to waste it on the outside air.

(iii) In locating a fireplace the need for a sufficient length of blank wall to place a bed is to be borne in mind.

(iv) If in the wall common to two rooms two fireplaces are to be built, they should be placed side by side, not back to back; as obviously they take
up less room, and masonry is economized in the
former mode.

Diagram No. 26.

Diagram No. 27.

92. II. The fireplace—

(1) The plan shows plainly what is required. The
sides should slope towards each other and the
back should have a slight slope or cushion of 3"
in 1 ft; these slopes all help to throw out heat.

(2) The hearth should not be more than 48" above
the level of the floor of the room, because—

(a) as hot air rises, the higher the hearth, the
deeper the layer of cold air on the floor; and also

(b) the higher the hearth the greater the chances
of burning wood and embers being shot out
into the room.

(iii) The plainer the front of the fireplace the better.
Indian masons are very fond of making wonder-
ful beatings and fluting, etc., which are always
in need of repair, and at the best are only places for dust to lodge on. A perfectly plain front with a carnel to support a straight mantelpiece is the simplest. The usual shape affected in India is particularly objectionable.

Diagram No. 28

Very good mantelpiece may be made by letting a plank of wood 2" thick, foot or so bread a little way into the wall.

(iv) In the small rooms generally built in our Rest-houses the mantelpiece should not be more than 6'—6" above the floor level.

94. III. The chimney—

(i) In pent roofed houses in the hills the chimneys should always be taken through the ridge, for—

(a) it is easier to make the roof water-tight then when the chimney goes through the slope of the roof;

(b) the draught is better as there is no downward current of air.

A position noticed in one of the Forest Rest-houses is particularly to be avoided.
Here as in (a) the smoke is almost invariably met by a down current from one side or the other, and the fire smokes so badly that it is impossible to sit in the room with it.

In cases of this nature the chimney must be taken well clear of the ridge as in (b). The bottom of the flue outlet must be at least 12 inches above the top of the ridge.

The chimney must be secured to the roof members by 1" dia. iron bars to prevent it being blown down in high winds.

(iii) The interior area of every chimney must be 144 square inches; for the ordinary 18 inch wall a convenient size of flue is 16"x9".

(iv) Every flue must be kept separate to the top, so that each chimney has its own separate stack.

(v) The chimney stack should have a projecting course in the masonry, under which the zinc or other flashing may be placed, and wrapped round the chimney.

Diagram No. 36.

(v) The inside of the chimney must be plastered smoothly, as the building arises, otherwise the rough surface hinders the ascent of the smoke, and causes smoke to lodge.
It is most important that the total area of the outlet must not be less than 144 square inches. preferably it should be increased by at least 1/24 per cent. The most satisfactory design is to keep the openings narrow and high; they should be at least 4" through. This prevents down draughts and birds from entering the chimney. A very simple method is to stand country tiles at end, 6 either side and 2 at each end 1 inch apart.

ROOFING

(1) Mud Roofing.

95. Composition. Mud roofing consists of rammed clay from 6", to 9" thick laid on tiles in lime carried on battens.

96. Laying. The tiles should be 12"x6"x2", and should be well soaked before being laid in mortar on the battens. The upper and lower surface should be pointed.

The mud should be stiff clay. After being excavated it must be spread out in the sun for several hours. It should then be stacked in heaps of convenient size, i.e., 50 or 100 cubic feet. Water should be added and the clay well mixed by treading in with the feet, until the whole assumes a consistency of stiff mortar. The clay should then be laid on the roof and beaten until quite hard. It will be finished off with a coat of mud plaster and finally leaped. A small slope is necessary on all flat roofs, i.e., 1 in 40.

(II) CORRUGATED G.I. ROOFING.

97. Corrugated Iron. The G.I. will be 24 S.W.G. The surface of the sheets will be quite clean, bright and free from iron rust. Any sheet showing a white powdery deposit must be rejected.

98. Laying. The sheets will be laid on horizontal wooden or iron purlines. There must be one at each end and one in the middle of each sheet. Each sheet should be laid with a 6" lap in its length over the sheet below it. The side laps will extend over two corrugations, and will be turned away from the rainy quarter. The sheets may be either rivetted or joined by means of limpet washers. The sheets will be secured to the timbering by means of G.I. screws, slips or hooked bolts passing through the sheet and round the timber. Each sheet will be held
down to the purlin by two or more screws or 30° bolts. Bolts will always be placed at the corners where four sheets overlap each other. Excellent rounded iron clips with little bolts are provided by the makers for fixing the sheeting to steel purlins. All clips and bolts must be galvanized. The bolt holes must be slightly larger than the bolts so as to allow for the expansion and contraction of the sheeting.

The ridges and hips must be covered with plain G.I. sheeting which will be riveted or fastened to the G.I. sheeting with flanged washers. The sheeting will be laid in lengths with an overlap of at least 9", the joints being set in yellow lead. All rivets, bolts, etc., will be set in white lead.

Wind ties will be fixed along the eaves of the roof and ventilators and will consist of iron bar. 3" x 3/4". The wind ties will be bolted down to the rafters in the same way as has been described for the sheeting, the holes in the corrugated iron being also made water-tight in the same way.

(Hi) Mud roof in the hills—Day Zone only.

99. The walls having been raised to the proper height, the space to be roofed is crossed by beams at suitable intervals. Over the beams 3" thick planks are laid, over which sheets of Shol putter, bich (Batula Ulillus) bark are spread, which are then covered with wet mud about 6" thick and well beaten down. Over the rammed earth a coat of mud plaster should then be applied. The mud used must be well prepared and applied with care. It must not be a hard stiff clay which soon cracks in the sun's heat, nor a loose sandy soil which will readily penetrate and wash down. Such roofs require frequent heating to consolidate the layer of earth and should be properly drained. As a bed for the covering of earth, a layer of reeds, twigs of straight branched shrubs and other similar material may be used instead of planks in the interior types of buildings.

Such roofs are very good for places where the rainfall is light, such as in Kanawur.

100. Slate roofs. Slates are generally used as a roof covering material in the hills; their qualities and dimensions vary considerably.
102. Varieties of slate. The Kanifan slate in the Kangra valley are about the best available in the Punjab hills, but the cost of their carriage being prohibitive, they are seldom used in the high hills.

103. The Talu slates found in Basahar are strong and of rough texture. The so-called slates in Kulu, Shala and sometimes in Basahar, are nothing but stone flags, but being available in large quantities are used in preference to other slates.

104. Selection of slates. The slates should be sound, with smooth and even surface, uniform in colour, free from cracks, faults, fissures and other imperfections. They should be rectangular and be gauged to the required dimensions. All slates with broken corners or cracks must be rejected.

105. Dimensions. The common dimensions used are 2' to 3' length, 1' to 2' width and 1'1/2" to 1'6" thickness. The smaller the slates used the more difficult it is to keep the roof water-tight, because of the larger number of joints. Smaller slates are more suitable for steep roofs, and have an additional advantage, in that they do not exact so heavy a pull on the nails.

The pitch for the slate varies from 22° (for larger slates) to 45° (for smaller slates).

106. Laying of slates. The common rafters of ordinary roofs are too far apart to receive the slates without intermediate support. The rafters, therefore, are covered with boards (laid either horizontally or obliquely), or with battens about 2'1/2" x 14" in section, nailed on to them. Battens are laid in horizontal lines at fixed distances apart equal to the gauge of the slates to be used. This distance from centre to centre is measured down the roof. Boarding is the more expensive, but helps to keep out wet. In order to make the roof water-tight the battens on either side of the ridge should be thicker to allow the topmost slates to be nailed projecting over the ridge. A thicker batten is also to be used at the eaves to give the lower layer a slight tilting. In the case of boarding a tiltingillet has to be provided at the eaves.

The slates to be laid out are to be of equal dimension, but, if for any reason the full number is not available, in
The slates should be laid with rough side up, except in the lower course where they are laid smooth side up so that they bed properly. Every course of the slates should break joint with the course below and above it. They should be laid in such a manner that there are two thicknesses at the hips and two elsewhere. The side joints should be kept as close as possible and arranged so that each comes over the centre line of the slate below. The upper course of the slates should overlap the lower one by 1/4" to 1/2" (3" being usual).

106. Fixing of slates. The slates are to be secured with galvanized iron nails. The nails to be used must be 2", or more, (depending on the thickness of the slates). They are to be fixed through holes punched in the slates, on to the boarding or battens below. The nailing may be done in the centre or the head. In the Punjab hills nailing at the head is usually adopted.

107. Zinc sheeting the ridge. In order to make the ridge water-tight, it should be covered with zinc sheeting. The sheets should overlap each other for at least three inches and be bent over the ridge pole (which should project three inches above the top of the roof) and to lap at least 1/2" over the top course of slates at each side of the ridge. They are to be prevented from blowing off or buckling up, by strips of hooped iron, painted with hot coal tar and bent over the sheets at intervals of two feet apart. The whole (including the hoop iron, ridge sheeting and the wooden ridge pieces) to be holed through. Sometimes wooden or stone capping is used to cover the ridges.

The hips should also be covered just as the ridges.

In slated roofs joints are generally made water-tight by cutting the slates obliquely to fit the angles; and by inserting galvanized iron sheeting below the slates. A tilting fillet raising the edge of the adjacent slates is fixed about 3" from the angle at each side and galvanized iron sheets dressed on the boards at the intersection, over the tilting fillet and 3" beyond the latter at each side.
156. Open slating. In the hills, sometimes the open slating method of laying is adopted. An equal number of rectangular and trapezoidal slates is indicated. The rectangular slates are laid first and nailed on to the battens by one or two nails, 2" to 3" from the head. The trapezoidal slates are then laid, breaking joints with the lower rectangular slates, the narrow end of the trapezoidal forming the tail. The overlapping is 3" to 4" on the sides. The next course is then commenced overlapping the lower course by 2" to 3," thus covering all the nail holes of the lower course. The upper ends of the rectangular slates are, as desired, that they leave a little gap in the joint to admit the nails of the overlapping trapezoidal slates.

157. Shingle roofs. Shingles are rectangular pieces of split wood and are used for roof covering where slates or other better roof covering materials are not available. Being split, not sawn, the surface lasts longer than planed.

The cutters of the Punjab hills are not well suited to a regular splitting and therefore do not render good shingles. Therefore split shingles are substituted by sawn shingles in better types of buildings. The exposed surface must be planed.

The shingles may be 3" to 3½" in length and 6" to 8" in width. The thickness in the case of split shingles may be ¾" to 1" and in cases even more, but in the case of shaven shingles it is usually 1". They should be of thoroughly seasoned wood and of decider so far as possible and must be made in a very careful manner.

A shingle roof is prepared in the same manner as the slate roof. Ridges, hips, valleys, chimneys and eaves are to be treated in the same manner as in the slate roof.

Where sawn shingles are used their backs may be grooved (section of the groove, ⅛" wide and 1/3" deep) along the lengths leaving 1" space from either edge, to avoid water coming into the side joints and facilitate its quick flow.

The shingle roofs may be given greater pitch than the slate roofs. It may be anything between 1 in 12 to 1 in 3, according to local conditions.
Wood-Work.

210. General. The timber will be selected, sawed, and dressed, as other similar timber found in the locality. It should be well seasoned, free from sap wood, checks, cracks, and There must be sawn square and straight and planed. The frames or timbers will be dressed and planed to the dimensions shown on the drawings. Unseasoned timber need not be planed.

All mortise and tenon joints must fit fully and truly without wedging and filling. All joints must be as simple as possible, and the bearing faces exposed to view if possible to ensure good fit.

Timber to be buried in the ground is to be well coated with asphaltum or tarred. Wood work exposed to the weather should be painted or treated with asphaltum. If seasoned, otherwise, it should be allowed to remain until seasoned, as a coating of paint will do more harm than good if applied to unseasoned timber. The ends of all beams, etc., which are to be embedded in walls, and sides of timbers which are to abut against walls, are to be treated with asphaltum or tar. No wood-work of any kind should be laid within 2 feet of a fireplace or flue.

111. Wood flooring. The floor boards will be as specified, well seasoned, free from knots and shakes. They will usually be 1 ½ to 2 ½ thick, 4” to 6” wide and 6 to 12 feet long.

The floor boards will rest on joists 18” apart, which in the case of ground floors will be fixed on “pillars” on foundations of 4” lime concrete on rammed earth. Free ventilation under the floor must be given.

Necessary ventilation may be obtained by the insertion of iron grates or terra cotta bricks at intervals along the outer walls. The grates should be placed so as to allow a free current of air to circulate under all floors. In double-storied buildings the ventilators are to be placed between the ceiling and the floor boards.

The boards should be dressed and planed square and true, with sides and ends parallel. They will be laid parallel to the long walls of the room. The ends will always rest on a joint and break joint.
Nails or screws will be given 2 at each end and one at every intermediate joint alternately on opposite sides of the plank. The planks may be forced together with a carpenter's clamp or wedges. The clamp will not be removed until the screws or nails have all been fixed. After it has been laid the floor will be planed and made perfectly true and smooth.

112. Doors and windows. Doors should not be less than 2 1/2" wide and 3-6" high. Doors of greater width than 3-6" will be generally made in two leaves. The size of doors and windows is the size of the clear opening between the frames, no allowance being made for rebating.

The joinery will be of the best wood obtainable. The planks should be cut from the log some months before being used. Priming will be usually 2" thick.

The stiles, rails, panels, sash bars must be accurately cut and fitted to the measurements given on the drawing. The width for door rails should not be less than 42", and for windows not less than 31". Before being put together all joints will receive a priming coat.

Weather boards must be provided on external doors and windows unprotected by verandahs.

113. Choolets. For ordinary doors and windows the choolets should not exceed 4"x3" in section. Choolets will be properly framed and morticed together. The head and sills will be hewn 6" long buried into the masonry. The choolets should be rebated on one side 2" deep and to the full width of the door or window, and have a return bead on the other side, to be chamfered as directed.

114. Windows. Will usually be made of 2" thick wood. The stiles, top and bottom rails should be moulded on one side and rebated 2" on the other to receive the glass. The size of the rebates must be a little larger than the size of the glass to prevent it touching the pane. Sash bars should be moulded and nailed on one side and rebated 2" on the other to receive the glass.

Glass-works.

115. Glazing. The glass should be sheet glass free from flaws, specks or bubbles. Standard size panes should
always be used. For doors and windows of Best-houses 21 oz. seconds should be used and for other buildings 15 oz. thirds.

116. Filling. The whole glass bar, but especially the rebate which is to receive the putty, will first be well primed to prevent the wood drawing the oil out of the putty. The back putty is then drawn along the inner edge of the rebate for the glass to bed on, the pane is then put in well bedded in the back putty, and secured in the rebate with 4 or more small nails, and by the front putty which should slope from the inner to the outer edge of the rebate. The putty must always be put on with a proper putty knife. Both back and front putty (where exposed) must then be covered with paint to protect it from the air, otherwise it will shrink and become loose as the oil dries out. Putty is made as follows. Take one seer finely powdered whiting, one chittack dry white lead, 6 chittacks raw linseed oil, 24 tolas linflax, mix well together and beat with a wooden mallet. If putty becomes hard it can be reduced by heating it slightly and working it up while warm.

In reputting panes of glass all the old putty is to be carefully removed and the rebates are to be thoroughly cleaned with linseed oil before being reputted.

PAINTING.

117. Painting. All exposed wood-work should be painted unless otherwise ordered, and it is also desirable to protect interior wood-work by painting and oiling or varnishing.

Painting should as far as possible be carried out in dry weather. Painting is best done departmentally or by piece work. In all cases all the materials should be supplied and mixed departmentally, and precaution must be taken that cheap bazar oils are not mixed in with the paints.

Where more than one coat of paint is required each coat must be of a slightly different tint, i.e., if the 3rd coat is to be white, the first coat will be of red lead, and the second will be slightly thinned with red lead. The first coat should always be mixed thinner than the following coats.
It is better to purchase ready-made paint from a good reliable firm (not from the banker) rather than allow a painter to mix his own.

118. Composition of Paints: (a) Base, (b) Carrier, (c) Drier, (d) Colouring matter or Pigment, (e) A solvent.

The base always determines the colour of the paint.

(a) Base. The base of all lead paints is either white or red lead. White lead paints are not suitable for delicate work, as the lead becomes discoloured. White lead has a good body, permanent, and is the base which is mostly used. It is obtained in the market either dry or ground in oil. It is a common practice to adulterate white lead with sulphate of baryta, whiting, etc. The presence of sulphate of baryta can be detected by the addition of nitric acid, which will dissolve the lead but not the baryta.

Red lead is largely used for painting iron work, and also for a drier. It is sometimes adulterated with brick dust, the presence of which may be detected by heating in a crucible and treating with nitric acid. The lead will be dissolved and the brick dust will remain.

Oxide of zinc is the base of most zinc paints. It has the advantage over lead paints that it is not liable to discoloration by sulphur, but it has the disadvantage that it has less body than white lead, is difficult to work and less durable. Lead driers must not be used with zinc paints.

(b) Carrier. Linseed oil is generally used. It oxidises and becomes thick on exposure to air. It is used either raw or boiled. Raw linseed oil is paler than boiled oil and is used for inside work, but is inferior in drying qualities. The drying of raw linseed oil may be improved by adding 1 lb. of white lead to every gallon of oil, and allowing it to settle for at least a week.

Boiled linseed oil is thicker and more darkly coloured than raw oil and cannot be used for delicate colours. When country linseed oil is used it must be boiled for 2 or 3 hours with red lead and 1 lb. of graphite to the proportion of one pound of each to every gallon of oil.
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allowing it to settle for at least a week.

Boiled linseed oil is thicker and more darkly coloured
than raw oil and cannot be used for delicate colours.
When country linseed oil is used it must be boiled for 2 or
3 hours with red lead and lime, in the proportion of
one pound of each to every gallon of oil.
(e) Driers. Litharge or lead oxide is the drier generally used, the proportion being ½ lb. to a gallon of oil. It has, however, a tendency to injure the colour of the paint and should not be used in the finishing coat.

(d) Pigments. Only standard colours are to be used.

(e) Solvents. Spirit of turpentine is used to thin prepared paints to make them work more smoothly. It used in excess it flattens the colours, which are then not durable, as the spirit evaporates, leaving an excess of colour not mixed, with the oil.

110. Proportions. The proportions in which paints should be mixed depends upon the nature of the pigments, climate, etc. The following proportions are given as a guide, but the correct mixture must be determined on the work:

**Normal Proportions.**

<table>
<thead>
<tr>
<th></th>
<th>1st cont.</th>
<th>2nd cont.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint</td>
<td>7 lbs.</td>
<td>7 lbs.</td>
</tr>
<tr>
<td>Linseed linseed oil</td>
<td>34 lbs.</td>
<td>44 lbs.</td>
</tr>
<tr>
<td>Drier</td>
<td>1 lb.</td>
<td>1 lb.</td>
</tr>
<tr>
<td>Turpentine</td>
<td>18 lbs.</td>
<td>1 lb.</td>
</tr>
</tbody>
</table>

**Lead paint proportions.**

<table>
<thead>
<tr>
<th></th>
<th>Lead paint</th>
<th>Linseed linseed oil</th>
<th>Raw linseed oil</th>
<th>Turpentine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside work</td>
<td>28 lbs.</td>
<td>14 lbs.</td>
<td>54 lbs.</td>
<td>1 lb.</td>
</tr>
<tr>
<td>Outside work</td>
<td>28 lbs.</td>
<td>4 lbs.</td>
<td>7 lbs.</td>
<td>1 lb.</td>
</tr>
</tbody>
</table>
130. Priming coat. A priming coat should be given, of red lead, or red and white lead mixed in boiled linseed oil only (7 lbs. lead to 4 pints boiled linseed oil). When dry, all holes and cracks must be filled in with putty and the whole surface rubbed down with pumice-stone or sand-paper and well dusted.

131. Second coat. The second coat will be of the desired colour, mixed as directed, and will be laid on in exactly the same manner as the priming coat. When dry the surface should be rubbed down with pumice-stone and glass-paper.

132. The correct application of paint. The paint should be applied with a brush (NOT RAGS) and spread as evenly and as smoothly as possible. To effect this, as soon as the whole or a convenient quantity is covered, the brush should be passed over it in a direction contrary to that in which it is finally to be laid off; this is called crossing. After crossing the brush should be laid off softly and carefully in the direction contrary to crossing, but with the grain of the wood, taking care that none of the cross brush marks are left visible. The criterion of good workmanship is that the paint is laid evenly and the brush marks are not observed. In laying off, the brush should be laid in that portion of the work already done so that the joints may not be perceived. Every coat must be perfectly dry, and be passed by the Range Officer in charge of the work, and all dust must be carefully removed before the next coat is applied.

Paint must not be allowed to settle in cans; to prevent this the painters must have a small smooth stick with which they must be made to stir the paint occasionally. If paint has to be laid on one side for a time in an open vessel, it should be covered with water.

133. Flat painting. When the work to be painted is subject to strong light, and is not of a very high finish, oil painting shows up every defect. In such cases it is desirable to use turpentine in the paint, the result being a flat instead of a shiny surface. The proportions to be used are 2 lbs. of white zinc, 1 lb. turpentine and ½ lb. boiled linseed oil.
124. Repainting old wood-work. The old paint should be carefully examined. If firm and sound the surface of the wood is to be rubbed down with pumice-stone or soap-stone, and washed with Dolly's earth and water, until all dirt, grease, blisters have been removed. To prepare dirty surfaces such as kitchen ceilings, doors, etc., for painting, a coat consisting of one jar glue and one chittack unslaked lime boiled in 3 years of water should first be given. The best method to remove old paint is to burn it off with blow-lamps or some good paint remover.

Painting Iron and Steel work.

All iron and steel work must have its surface protected from rust. Once metal begins to oxide it is most difficult to prevent. Paint or any other protecting coat will peel off if applied to a surface containing any particles of rust. Whenever possible the metal should be black hot and immersed in a trough of boiled linseed oil. If this is not possible the metal must be thoroughly cleaned from rust and dirt by scraping and brushing with a wire brush, and then coated with boiled linseed oil or a priming coat. Iron and steel can be temporarily protected from rust by painting it over with white-wash (lime) or by covering it with slaked lime.

Iron work which is to be embedded in walls must be coal-tarred. (See Note on Coal Tarring).

Red lead paint must be used for important structural iron work, mixed in the following proportions:

Red lead 100 lbs. (see below).
White zinc 20 lbs.
Raw linseed oil 5 gallons.
Turpentine 34 plints.

For 3 coat work, 60 lbs. for the first coat, 30 lbs. for the second, and 100 lbs. for the third.

For important iron work or roofs, red oxide of iron paint should be used. A gallon of red oxide paint mixed in the following proportions:

Red oxide powder, dry 10 parts by weight
Linseed oil, raw 4
Linseed oil, boiled 1 part by weight
Turpentine 1
For the outside of Steel Water Tanks:—

Red lead, dry  ...  lbs.
Raw linseed oil  ...  5 pints.

By mixing in 1 lb. of lamp black chocolate colour will result:

The inside of water tanks should be painted white for which the following proportions may be used:—

White lead, dry  ...  25 lbs.
Boiled linseed oil  ...  24 pints
Raw linseed oil  ...  6 pints
Turpentine  ...  1 pint

126. Brushes. New brushes must be placed in water for 2 or 3 hours before use, then taken out, shaken free from water and allowed to dry for a short time before being put into the paint. When a brush is to be used for another colour or to be put away, it should be cleaned at once by dipping into turpentine off, which must afterwards be shaken out. A brush in which paint is allowed to dry is spoilt. Old brushes should be kept in water or raw linseed off.

127. Varnishing. Varnish must not be used on structures which are to be exposed to the weather. Hard drying copal or oak varnishes are most suitable for the interior and furniture. It is advisable to thin copal varnish with one quart of turpentine to one gallon of varnish. The surface to be varnished must be thoroughly cleaned, sand papered and first painted with a coat of glue size. This will be made of good clean glue of a consistency to run freely off the brush when hot. Two seers of glue boiled in 10 seers of water is about correct.

One pint of varnish should cover about 160 square feet.

128. Oiling. It is more economical than varnishing or painting, but is much more difficult to obtain good results. Good boiled oil spread in a thin film on glass should become quite firm within 24 hours.
The following forms a good coating for wood work—
3 lbs. boiled linseed oil of good quality.
1 lb. turpentine.
1 lb. bees wax.

The oil and wax to be heated over a slow fire until the wax is melted, and, after the mixture has cooled, turpentine to be added and the mixture to be applied in two or more coats as desired.

COAL-TARRING.

128. General. Coal-tar must not be applied to green wood. All wood must be well seasoned and dry before tarring.

Before applying, the surface of the wood or iron must be well cleaned.

129. Ingredients. The tar will be thinned with kerosine oil or country spirit in the following propor-
(a) Four parts tar to one part kerosine.
(b) One gallon tar to half a pint country spirit.

The above proportions may be altered to suit conditions.

To prevent tar running free add two lbs. of unslaked lime to every gallon of tar.

130. Application. The tar and kerosine should be mixed together cold and then heated to nearly boiling point. The safest method to accomplish this is to use 2 tins of different size. The mixture is poured into the smaller, and the larger is filled with water. The smaller tin is placed inside the larger which is then heated until boiling, when immediately the tin containing the mixture is removed.

Immediately after application the tarring should be dusted over with fine coal dust, if possible.

Best results are obtained by clipping the article into the hot tar. Iron work must always be well-heated before the tar is applied.

Not less than 10 lbs. tar should be used per 100 square feet of surface tared.
APPENDIX

GLOSSARY OF USEFUL TECHNICAL TERMS.

Lime.

Pozzolana is Pure lime which will set in water.

Hydraulic lime is one that will set within 7 days under water.

Brick-work.

Bed Joints. The mortar joints normal to pressure.—

(a) In walls with vertical faces the bed joints would be horizontal.

(b) In batter walls they would be at right angles to the batter.

(c) In arches the joints would be normal to the arch.

Quoins. The external corners of the building. The name is sometimes applied to bricks or stones which form the Quoin, e.g., quoin brick, quoin stone.

Perpend. The vertical joint on the face of the wall. In plain walling it is necessary for good bond that these joints in alternate courses should be vertically one above the other.

Stretchers. Bricks or stones laid with their greatest lengths parallel to the face of the work.

Headers.—Bricks or stones laid with their greatest length perpendicular to the face of the work.

Bets. Pieces of brick, usually known, according to their fraction of the whole brick, as $\frac{1}{3}$ or $\frac{1}{2}$ bate.

Lap. The horizontal distance between the vertical joints in two successive courses. This should be one-fourth of the length of a brick.
Queen Closer. Bricks made the same length and thickness as ordinary bricks, but half the width, placed usually next to the quoin header to obtain the lap.

King Closer. Bricks cut longitudinally in half or specially moulded bricks of this size.

Toothing. The usual method of leaving a brick wall which is to be continued at some future time is to tooth it, which consists of leaving each header, projecting 2, 1/2" beyond the stretching course above and below to allow the new work to be bonded to the old.

Racking. Racking is the term applied to the method of arranging the edge of a brick wall, part of which is unavoidably delayed while the remainder is carried up. The unfinished edge must not be built vertically or simply toothed, but must be set back 2, 1/2" at each course.

Bond. Is the name given to the arrangement of bricks or stones of each course so as to ensure the greatest possible amount of lap, and also to prevent the vertical joints between any two courses making a continuous straight line.

English Bond. Consists one course of headers and one course of stretchers alternately. In this bond bricks are laid as stretchers only on the boundaries of courses, thus showing on the face of the wall, and no attempt should be made to break joints in a course running through from back to the front of a wall. The course which consists of stretchers on the face is known as the Stretching Course, and all in course above and below it would be headers with the exception of the closer brick, which is always placed next to the quoin header to complete the bond, and these courses would be called Heading course.

Herringbone Bond. The bricks in this method are laid at an angle of 45 degrees, commencing at the centre line and working towards the face bricks. Herringbone bond is used for walls four bricks and upwards in thickness.

Jamb. The vertical sides of door and window openings are known as jamb.
Squint Quoins. If two walls meet and enclose an
angle other than a right angle in plan, the junction is
known as a Squint Quoin.

Pilaster. A horizontal and usually projecting course
built at the base of walls to protect walls from injury and
give additional strength and to improve the appearance
of the structure.

String course. The name given to horizontal courses,
sometimes projecting and moulded, built in the faces of
walls to act as a tie and architecturally to emphasize
the horizontal divisions in a building.

Technical Terms Used in Connection with Arches.

Vousoirs. The bricks or stones, usually wedge-
shaped on the face, which compose the courses of the
arch.

Springs. The extreme or lowest vousoirs of the
arch.

Skeewlocks. These are the upper surfaces of the
abutments or piers from which an arch springs and are
so formed as to radiate from the centre of the arch.

Key. The uppermost or central brick or stone of the
arch.

Intrados or soffit. The under or concave side of the
arch.

Extrodes or back. The upper or convex side of an
arch.

Impost. The upper part of the pier or abutment on
which an arch rests, or from which it springs.

Springing points. The points from which the curves
of an arch commence, as seen in elevation.

Ring courses of Arches. The name given to those
courses of brick-work that partake of the circular form,
as seen in the face of the wall.

Lacing courses. The continuity of the ring courses
are sometimes broken by a bonding or lacing course. The
object of a lacing course is to distribute the pressure more
evenly over the sectional area of the arch.

Label course. The name given to a course of bricks
laid flatwise on an arch and deepening it. These courses
usually project, and are moulded and weathered on their
upper side to throw all rain water clear of the arch.
Rough Arch. Arches constructed of ordinary uncut bricks are known as rough arches.

Inverted Arch. These are rough arches inverted, springing from piers or abutments upon which the bulk of the weight is concentrated and with which there would be a possibility of unequal settlement with the remainder of the wall due to the body of the wall or ground under the foundation being subjected to a non-uniformly distributed stress. Their effect is to distribute the pressure uniformly over the whole of the wall or along the whole length of the foundation.

Trimmer Arch. These are a form of rough arch adopted for supporting hearths in front of chimney breasts, and having an abutment against the trimmer or trimmer joint.

Gauged Arch. All arches in which bricks are cut to definite sizes and shapes are known as gauged arches.

Springer. The lowest stone in an arch.

Technical Terms in Masonry.

Apex or Saddle Stone. The highest stone of a gable end cut to form the termination of two adjacent inclined surfaces.

Bed surface. The surface of a stone perpendicular to the plane, which surface must be worked into one plane surface.

Blocking surface. A course of stones erected on the cove, the object being to gain extra weight to fall down the cornice, to form a parapet.

Bonders. Long stones placed through from front to back of a wall to tie the wall transversely. These may be either headers or through stones.

Copings. The highest and covering course of masonry, forming a waterproof top, to preserve the interior of the wall from wet.

Cornice. A moulded course of masonry crowning buildings, generally having a large projection to throw off the rain water.

Drip. This is a thin mortar, which is poured over stones when brought up to a level surface to fill up any interstices between the stones in the hearing of the wall.

Drum Stone. A projecting stone having a bevelled under-surface, to throw water clear off walls, doors, windows, etc.
Ashlar. Ashlar is the name applied to stones that are carefully worked, and are usually over 12" deep, and have joints not more than 1/8" thick.

Some Technical Terms Used in Steel Girder Work:

- **Effective span.** The distance between the centres of the bearing surfaces of the girder on the supports. This is taken for purposes of calculation as the girder is usually cambered to prevent the bearing surface of the girder resting on the outer edge of the stone template.

- **Effective load.** The effective span in feet multiplied by the weight of the distributed load per foot run.

- **Bearing surface.** The part of the lower face of the girder which, when loaded rests upon the support.

- **Camber.** This is a vertical curve in an upward direction from the bearing points. Beams are cambered to allow for the deflection of a beam when loaded. Cast Iron beams should have a camber of 1" for every 10 ft. of span; steel girders 1/2" in 10 ft.
FRONT ELEVATION

SCALE 1" = 1 foot

SECTION SCALE 1/4" = 1 foot
TECHNICAL ORDER NO. 11.

PREPARATION AND REVISION OF WORKING PLANS.

Section 7—General.

1. Working Plans (or working schemes, planting schemes, regional plans, watershed plans, etc., as the requirements in each case may be) shall be prepared for all forests (or areas) or group of forests (or areas) under the management of the Punjab Forest Department. In preparing and revising such schemes the provisions of the National Forest Policy of India, 1952, shall be kept in view.

2. The principal object of the preliminary report for a working plan revision is to examine the results of past working, to decide how far the prescriptions of the previous plans should be followed and where and in what direction modifications are necessary. In case of new working plans, the preliminary report will contain a short description of the forests for which it is contemplated to frame a working plan, facts relating to their management, working and reproduction; the future treatment recommended along with reasons for the same; propositions regarding the basis on which it is intended to build the plan of exploitation and management (whether on area, or volume with area check), and proposals with regard to valuation surveys. A small scale sketch map showing roughly the proposed working circles and any other information that can conveniently be included with the object of more clearly setting forth the proposals for future working than is possible by means of manuscript description above shall accompany the report. The report shall also suggest if the appointment of a whole-time Working Plan Officer would be necessary and if so for how long and what staff if any would be required and how much can be spared from the territorial circle concerned. The report shall also suggest the maps which should be prepared as a part of the preparation or revision of the working plan. The report shall also specify the equipment proposed to be given to the working plan officer and his parties with full justification with recommendation as to how the expenditure is to be met and what if any can be met out from the existing stocks. In short, the preliminary working plan...

*Throughout this Chapter the words ‘Working plan’ include working scheme, planting scheme, regional plans, watershed plans as the requirements in each case may be.*
will be the working plan itself in miniature, leaving the details and the comprehensive presentation of the subject to the working plan officer. Chief Conservator of Forests shall pass appropriate orders on the report, which shall remain standing. These modifications shall only be considered as a result of the detailed inspection of forests and examination of relevant material by the working plan officer who will submit a detailed report for the reconsideration of a specific point if necessary. The channel of communication will be the Working Plan Officer, Conservator Working Plan (if there be one) Conservator (Territorial) and Chief Conservator of Forests.

3. The territorial Conservator shall submit the Preliminary Working Plan Report in good time to Chief Conservator of Forests calculating very carefully that the least sanction is possible to be accorded before the period of the existing working plan expires. For any areas or forest tracts taken over for the first time or those not under any working plan it shall be obligatory to ensure their being brought under some kind of working plan however simple it may be. The territorial Conservators are responsible to see that all areas within their circles are under working plans and that sanction of the competent authority exists for areas not destined to be under working plans.

4. If the preliminary report there is no obligation on the territorial Conservator to make definite proposals for future management on all points covered by the report. Frequently it is necessary for the Working Plan Officer to make more detailed enquiries and to collect important facts and figures before definite proposals for future management can be made. On the other hand, if the past management has been quite satisfactory and it is to be continued without radical alterations, the territorial Conservator will be in a better position to make definite proposals for the future. In the preliminary report, therefore, the territorial Conservator will make it clear what points are left for future consideration and what information the Working Plan Officer will have to collect. Where the territorial Conservator makes definite proposals for future management in the preliminary report these will be regarded or guides to the Working Plan Officer, which can be modified later if during the preparation of the working plan some alternative proposals are considered preferable. In all cases, however, any alterations in the original preliminary report, or taking decision on the
Section 2. Personnel

5. The staff for each working plan will be decided by the Chief Conservator of Forests on the submission of the Preliminary Working Plan Report.

6. The preliminary working plan report will be the instructions to the Working Plan Officer regarding the preparation of the working plan. His duty will be to obtain all the necessary information from the territorial divisional office for the preparation of Part I. He will carry out the necessary field work, will describe and allot compartments to working circles, felling series and periods, as necessary. He will also do the stock mapping into species, age classes, etc., and during the course of his field work will investigate the question of the real and normal growing stock and increment. The Working Plan Officer is also expected to make himself fully acquainted with the technique of the preparation of working plans with the Indian Forestry Literature, on the subject and, with the publications of the Forest Research Institute. The Working Plan Officer may state his views regarding any modifications in the preliminary report which he thinks should be made for the consideration of the Working Plan Conservator (if any) and final approval by the Chief Conservator of Forests through the territorial Conservator.

7. It is absolutely essential that a spirit of cooperation and mutual assistance should prevail between the Working Plans and the Divisional staff. The Divisional Forest Officer will furnish the Working Plan Officer with relevant records to enable the latter to obtain facts and figures; he will place accurate maps at his disposal, seeing that all corrections of boundaries have been made and new roads and buildings entered. The Divisional Forest Officer will have statements of revenue and expenditure prepared, but the Working Plan Officer must satisfy himself that the statements are correct and contain all the necessary information. Statements of past yield will be obtained by the Working Plan Officer direct from the control forms and other subsidiary returns. The Range Officer should meet the Working Plan Officer when first he enters his Range and must afford him all assistance in
starting field operations; the best Forest Guard must accompany the Working Plan Officer and enumeration parties when work is proceeding in his beat. Transfers of local territorial staff shall be avoided when a Working Plan is in the course of preparation or revision.

Section 3. The Organisation of the Forest Under Working Plans.

18. The Working Plan Conservator (if any otherwise the territorial Conservator) is responsible for the work of the Working Plan Officer. He will see that the field work is properly carried on, that the allotment to working circles and periodic blocks is on sound lines, and that the work is generally carried out accurately and expeditiously. The Conservator will supervise the writing of the plan and will correct and amend it, at his discretion. He will see that the form of control is suitable and that the compartment histories are accurate.

19. The first duty of a Working Plan Officer in the field is to examine his territorial units (blocks and compartments) and see that they are adequately demarcated and sufficiently sub-divided for purposes of the new plan, as outlined in the preliminary report. A clear grasp of the right position is absolutely essential. Existing compartment boundaries, names and numbers shall not be changed unless absolutely necessary, and in case of change, the Chief Conservator of Forests's sanction must first be obtained. In renumbering some definite order, as W.I., and W.S. must be decided on and observed throughout. Where it is necessary to sub-divide a well-known compartment, this should be done by breaking it up into sub-compartment. In this case the sub-compartment must be permanent units, clearly demarcated on the ground and shown on the map.

20. The maintenance of the external boundaries of the estate and of the boundaries of such interior-private lands as have been excluded from the area of the legally notified reserved or protected forest is one of the first duties of the executive officer-in-charge (viz., the Divisional Forest Officer). In order to ensure that this important work be attended to, it should be prescribed in working plans that a certain proportion of the length of boundary or portion of the estate shall be examined annually by a responsible officer, and any defects which may be brought to light rectified. During the course of the revision the Working Plan Officer (and his staff) will
have frequent opportunity of examining the demarcation and it is part of his duty to see that this is generally in order, failing which it is incumbent on him to report the matter to the territorial Conservator. Boundaries are demarcated in several different ways; the outer line with ditch and stone monoliths in the plain, while in the hills natural features, such as ridges and nullas, are frequently adopted. The boundary must be clear on the ground, the position of the pillars on the ground and their numbers shall correspond with the map, and usually each pillar shall be visible from the next one on either side.

11. A forest block is either a natural division of a woods, forest estate or is part of large tract of forest separated off either for purposes of the record of forest rights, when it is frequently designated a settlement block, or for other administrative reasons. Forest blocks bear a local proper name and may be of any size. Some forest divisions, more especially in the hills, are divided into separate entities known as blocks or forests, other divisions are merely divided into compartments.

12. A compartment is a portion of a forest that is as far as possible homogeneous throughout its extent as regards soil, aspect and composition of the growing stock. The compartment is the permanent working plan unit. It must be distinct on the ground and on the map. This latter point is of greater importance than the exact homogeneity of the crop it contains, but as far as possible each compartment shall be capable of treatment under one and the same silvicultural system and of inclusion in the same working circle. A compartment must be bounded by fixed lines, paths, streams, nullas, ridges or other readily ascertainable features.

13. The division of a forest into compartments is the very foundation on which is built the structure of the detailed management. This division into suitable compartments is the primary duty of the Working Plan Officer. The size of compartments will vary with the intensity of the management, all the latest plans have considerably reduced the size of the compartment and it is probable that finally it has not even now been reached. A reasonable mean in the size of compartments must be maintained; compartments should be neither too small nor
too big. If too small, their number becomes excessive; if too big, they are impossible to describe.

14. Compartments may be numbered separately for each block, or they may be numbered serially throughout the division. It is important that the subordinate staff must become acquainted with the numbers of the different compartments, and to change their numbers is most undesirable. Compartments must therefore be numbered on the ground either by small engraved stones, numbered boards, or by painted stencilled numbers on trees or any other suitable method. Compartments are numbered in Arabic numerals 1, 6, 24 and should be shown in black ink on the map.

15. A sub-compartment is a division of a compartment either permanent or temporary. Sub-compartment are made when it is desired to split up an old established compartment with a well-known number, or where the composition of the crop renders such sub-division necessary. Again, where part of a compartment is high forest, and the rest jambo, sub-compartment may be formed. The boundaries of sub-compartment are not necessarily permanently fixed; they are generally shown by a colour wash on the map and designated with a small letter. Therefore, where forest blocks exist a particular sub-compartment would be designated—Bhandara, 31, a.

16. A coupe is the area set aside for felling in a single year. It is used more especially in the case of simple coupes and coupes with standards. It is not a fixed geographical entity, nor is it a permanent working plan like a compartment. Coupes are given a Roman numeral where it is necessary to give them numbers.

Section 4. The organisation of the working plan.

17. Standard text books deal in considerable detail with the silvicultural management of the different species of northern India, and with all aspects of practical management under the standard silvicultural systems. Certain sections have however been reproduced here for the sake of completeness.

The Constitution of Working Circles. 18. A working circle is an area subject to one and the same silvicultural system and method of treatment and
which is exploited by a distinct series of operations. It may consist of one or more felling series. The number of working circles should not be unduly increased. The greater the number the more complicated the control. Having decided on the silvicultural system or systems, it now becomes necessary to allot compartments to working circles in accordance with the way in which it has been decided to treat them. The broad outlines of the working plan having already been laid down, the Working Plan Officer will consider the question of the allotments to working circles at the same time as he describes the compartments. In order that a working circle may be properly constituted it should contain crops of well graduated ages. As, however, under present circumstances the distribution of the age classes is never normal, the Working Plan Officer must do the best he can with crops at his disposal and must make the best possible arrangements to obtain greater normality in the future.

A working circle comprising as it does forests under one and the same method of treatment, need not be in one piece; in fact, it is seldom so. As area is the foundation on which the constitution of a working circle managed under the uniform system rests, it is essential that the whole area allotted to the working circle or at any rate the greater portion of it should be capable of being managed and regenerated under the silvicultural system prescribed. When large areas of fir forest which it is never proposed to regenerate are included and shown in the allotment to periodic blocks, an entirely wrong picture of the constitution of the working circles may be presented, and grave errors in allotment to periods may arise. If any compartment contains appreciable areas of forest incapable of regeneration under the prescribed system either the whole area only should be shown or the unproductive area of fir or broad leaved trees should be formed into a sub-compartment and excluded from the working circle altogether. It is also incorrect to imagine that definite areas cannot be prescribed for regeneration or afforestation in a working circle managed under the selection system, should silviculture require this treatment over limited defined areas, as opposed to the general management under the principles of selection. Such areas are shown pink on the map.

19 A felling series is part of a working circle comprising a separate series of age classes. Felling series are the constitution of the felling series.
constituted from the area of the working circle in order to provide a sustained yield of forest produce to one or more markets or to distribute forest works of all kinds over one or more ranges, although the constitution of separate falling series for this latter purpose alone is not necessary. Each falling series is a self-contained unit of management, with a separate calculation of the yield and a separate series of all agricultural operations. Where there is a local demand for the produce, where rights have to be annually satisfied at a reasonable distance from the right-holding villages and local grazing rights have to be met, in these cases comparatively small falling series will be indicated. Beyond what is necessary to comply with the above considerations the number of falling series should not be unduly multiplied. If too numerous, the number of separate operations become inconveniently great and the work of a given year is correspondingly scattered.

The allotment to periodic blocks is one of the greatest faults in working plans. The first essential to a correct allotment is a reasonable sub-division into compartments. In many divisions these are far too big. It is impossible to deal with compartments of 200 acres. Compartments of not more than 100 acres should be aimed at. In the irrigated plantations 50 acres is the standard. In making any allotment of compartments to periods, the orders of the Forest Settlement must be given the fullest consideration. The Chief Conservator will not permit any allotment to periods under which the area to be regenerated cannot be closed in accordance with the provisions of the forest settlement. There is no necessity to concentrate large areas under regeneration and this policy has every disadvantage; the fire hazard is greater, it is impossible to close the grazing, no local supplies of timber will be available once the area has been regenerated and the work of regeneration is not distributed amongst the staff. The allotment to periods should be scattered over the area of the working circle so that all areas allotted to P. B. I can be closed to grazing; thereafter the settlement will naturally follow as far as possible the distribution of the age classes on the ground. Where the regulation of the yield is based on area it follows that areas allotted to periods must be not areas.
and where the question of quality classes is a factor of importance not reduced areas.

21. As the new Statistical Code lays down 4 inches diameter classes as standard it is necessary to adopt this classification.

22. The following standard diameter classes are therefore prescribed for adoption throughout the State. All future revisions of Working Plans will be made in these standard diameter classes and elsewhere the early introduction of these diameter Classes will be considered.

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<thead>
<tr>
<th>TABLE OF STANDARD DIAMETER CLASSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 8&quot; diameter</td>
</tr>
<tr>
<td>8&quot; diameter ago but less than 10&quot; diameter</td>
</tr>
<tr>
<td>10&quot; Dima</td>
</tr>
<tr>
<td>14&quot; Dima</td>
</tr>
<tr>
<td>20&quot; Dima</td>
</tr>
<tr>
<td>24&quot; Dima</td>
</tr>
<tr>
<td>28&quot; Dima</td>
</tr>
<tr>
<td>32&quot; Dima</td>
</tr>
<tr>
<td>Over 36&quot; diameter</td>
</tr>
</tbody>
</table>

23. By rotation is meant the predetermined period during which it is intended to cut over a working circle. Rotation really refers to even-aged crops. As regards solitary trees or the individuals of a copped crop, considered singly the age at which they become exploitable varies from tree to tree according to the special environment of each, and in such cases the exploitable size is of more importance than age. Nevertheless in a selection forest a rotation calculated to produce an average exploitable tree must be determined for the purpose of calculating the yield, but this average tree will vary according to the different quality classes of different sites.
23. (a). The first essential of a rotation is that it produces a crop of trees for which a demand exists and the second that this particular class of crop shows satisfactory financial results. From an exploitation point of view it may be very desirable to grow trees to 30" diameter but under certain circumstances it may be financially very unwise to do so. It is useless growing coppice for firewood when there is no demand for this material, nor is it profitable to produce small low class material when the local market demands high class sawn logs and is prepared to pay for them. A study of this section in existing working plans will provide sufficient examples of how the rotation may be determined. Rotations have lately been lengthened for the coniferous forests of the hills, and vary from 120 to 160 years, the latter figure being generally accepted as correct where timber in the form of the R. G.Sleepers is required. In the dry zone considerably longer rotations appear to be excessive. Irrigated plantations should be felled first at the earliest possible rotation to reduce interest charges. The exploitable size which refers only to individual trees is entirely a different matter. In the rotation the former is of first rate importance only in selection forests whereas rotation is the dominating consideration in even aged crops.

24. Much greater attention must, in future, be paid to the consideration of the actual growing stock and increment as compared with the normal obtained from yield tables. The Forest Research Institute yield tables for Picea longifolia and Cedrus deodara will be made use of in all future working plans. The C. A. I. and M. A. I. of crops are read from the yield tables. The C. A. I. of the diameter classes is obtained from curves better than direct from the table of ages and volumes. The Eulitz deoder figures, i.e., the mean of quality class III are as follows:

<table>
<thead>
<tr>
<th>Diameter Class</th>
<th>Age</th>
<th>C.A.I.C.R.</th>
<th>Growth per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot;-16&quot;</td>
<td>65</td>
<td>1.4</td>
<td>4.2</td>
</tr>
<tr>
<td>16&quot;-20&quot;</td>
<td>70</td>
<td>1.9</td>
<td>4.4</td>
</tr>
<tr>
<td>20&quot;-24&quot;</td>
<td>100</td>
<td>2.1</td>
<td>4.7</td>
</tr>
<tr>
<td>24&quot;-28&quot;</td>
<td>120</td>
<td>2.3</td>
<td>4.9</td>
</tr>
<tr>
<td>28&quot;-32&quot;</td>
<td>140</td>
<td>2.5</td>
<td>5.2</td>
</tr>
<tr>
<td>32&quot;-36&quot;</td>
<td>160</td>
<td>2.7</td>
<td>5.4</td>
</tr>
</tbody>
</table>
Schnieder's formula for the calculation of the growth per cent of individual trees has been found by experience to be sufficiently accurate for all practical purposes. The growth per cent of trees in area under regeneration under the Uniform System is of very great importance and working plans must give consideration to this matter.

25. As the Forest Research Institute have now standardised the quality classes of deodar, kail and chir, etc., Working Plan Officers will, in future, allot all compartments to their respective quality classes by the method of height over age or by measuring the heights of mature trees which have completed their height growth and comparing their height with the curve attached to the yield table. For the purpose of obtaining the age of standing trees specially long increment borers are now available. Ages of pole crops may also be obtained from trees felled in thinnings.

26. The enormous difference in yield capacity between different quality classes renders it essential under certain circumstances when allotting areas of different quality to the various periodic blocks or when fixing the annual yield by area, to make due allowance for the difference in yield capacity if a sustained annual yield is required. In the hills where, owing to the record of eight, periodic blocks have usually to be widely distributed over the area of the division difference in quality will average themselves out and reduced areas may not be necessary. In the irrigated plantations reduced areas will always be used in arranging the annual coupes.

27. A ready indication of the yield capacities of different qualities is given by the M.A.L. curves. Thus for chir with a rotation of 100 years, the yield capacities for stem timber are as follows:

<table>
<thead>
<tr>
<th>QUALITY</th>
<th>M.A.L.</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>107</td>
<td>74</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>1.44</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Yield capacity of different quality classes.
Thus taking quality class II as unit, the reduced area of a working circle is obtained by taking:

1. Area of quality class I compartments $\times 1.44$.
2. Area of quality class II compartments $\times 1$.
3. Area of quality class III compartments $\times 0.69$.

In the case of the irrigated plantation, local quality classes will have their different yield capacities in cubic feet stacked at rotation age and these figures will be used as the basis of the ratios of the different quality classes for the calculation of reduced areas.

Volume Tables

The Forest Research Institute have published volume tables for deodar, kail and chir both in standard stem timber and in commercial timber. Trevor’s Kuhl volume tables have been largely used both in the Punjab and Kashmir. In connection with the Trevor’s revision of Trevor’s Working Plan these deodar volume tables which are $(A)^{2} \times$ length measured over back have been submitted to a detailed criticism and reduction to the more usual standard measurement of $II^{2} \times$ length not including bark and a correction has been made in the two lowest diameter classes. Trevor’s volume table may read as follows:

<table>
<thead>
<tr>
<th>Diameter Class</th>
<th>Kuhl</th>
<th>Average</th>
<th>Mean of</th>
<th>O.F.R.</th>
<th>Standard errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot;-16&quot;</td>
<td>14</td>
<td>14</td>
<td>13</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>16&quot;-20&quot;</td>
<td>43</td>
<td>46</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20&quot;-26&quot;</td>
<td>82</td>
<td>83</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26&quot;-32&quot;</td>
<td>123</td>
<td>125</td>
<td>125</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32&quot;-40&quot;</td>
<td>172</td>
<td>168</td>
<td>170</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40&quot;-50&quot;</td>
<td>218</td>
<td>215</td>
<td>215</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It will be seen that Trevor’s Kuhl averages are, within experimental error, the same as the mean of Forest Research Institute quality I.[1]

29. For all purposes of yield calculation, commercial volumes are to be preferred to standard volumes. The latter will of course be used for comparing the actual growing stock with the normal from yield tables.
30. The following volume tables founded on the Forest Research Institute figures but rounded off to the nearest five cubic feet will in future be used in all working plans:

<table>
<thead>
<tr>
<th>Diameter Class</th>
<th>Quality II</th>
<th>Quality II</th>
<th>Quality II</th>
<th>Quality II</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot;-14&quot;</td>
<td>13</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>16&quot;-20&quot;</td>
<td>15</td>
<td>16</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>20&quot;-24&quot;</td>
<td>20</td>
<td>22</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>24&quot;-28&quot;</td>
<td>25</td>
<td>27</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>28&quot;-32&quot;</td>
<td>30</td>
<td>32</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>32&quot;-36&quot;</td>
<td>35</td>
<td>37</td>
<td>39</td>
<td></td>
</tr>
</tbody>
</table>

*Note: (1) The figures can be used quite well for Pinus roxburghii.
(2) Quality Class I is not required in the Pashig.
(3) The figures are from Trevor's Khas Working Plan.

31. The uniform system of management has been employed in the pine forests of the United Provinces for many years and was introduced into the Punjab by Jersam in his plan for the forests of Murree and Kotli. Provided the area is carried out in a reasonable way and the strictest attention is paid to departmental burning, cleaning, thinning and other measures of fire protection, this system is by far the best for the chir pine. Very excellent results can be seen in Rawalpindi, Kangra, and Kullu. This system was also introduced in Kulu by Trevor for deodar, Kail and fir and has now been in operation for many years. Regeneration of all species has been obtained under this system and the new crops are far better than any thing obtained in the past. A modified system has also been introduced into Chamba and Balsam with satisfactory results. This method has also been successfully adopted in Kashmir and is now the standard to be.
employed wherever the ground permits. The present distribution of the age classes throughout the compartments is, however, very irregular and the complete adoption of the uniform system would result in a great sacrifice of immature timber. It is usually impracticable so to sub-divide the compartments and to allot only one age class to each sub-compartment. Consequently the uniform system is modified to allow of the retention of a compact group of well grown poles as part of the future crop. A certain amount of irregularity in the young crop is not only recognized as inevitable but is welcomed. The system is known as the ‘Punjab Shelterwood System.’ Elsewhere, where the steepness of the hills inhibits any such system of working, the selection system is employed. It is laid down that any selection system must provide for normal regeneration and the proper distribution of the age classes, and that the executive staff must see that this is obtained otherwise the system degenerates into pure lumbering. Another most important point is that when marking, all silvicultural operations must be carried out at one and the same time.

In the case of the irrigated plantations the silvicultural system is best designated coppice or coppice with standards although the new crop is largely derived from seed.

Definition of the Final Yield: 32. The definition of the final yield, as given in the Glossary of Technical Terms, is modified as follows:

‘Final Yield’—The material which counts against the prescribed yield derived from clear or regeneration fellings or from trees which have reached exploitable size.

The exploitable trees in blocks other than P. B. I. are geographically out of place, but there is no reason for excluding them from the final yield as they have already attained the size required in order to fulfill the objects of management.

The final yield is prescribed by volume and ordinarily consists of the volume of trees of over 10" diameter in P. B. I., no allowance being made for increment, plus the volume of such exploitable trees as are prescribed for felling outside P. B. I.
33. This most important part of the working plan, the Calculation of the yield, was discussed under item 16 of the Third Silvicultural Conference of 1926, reproduced on pages 251–277 of the proceedings and two valuable papers were contributed by Simmons and Glover; the former dealing with the general aspect of the calculation of the yield in 3 types of forests, I Regular forests or conversion of irregular forests to a series of even aged woods, II Irregular forests, and III Forests where an equality of yield is a feature dominating management. Simmons' recommendations of methods of yield calculation are sound and can be adopted with confidence. In case of uniform working circles, volume plus area is really the most satisfactory method and this was the method adopted in Kulu. It has failed owing to the excessive revenue fellings carried out outside P.B.I. in spite of distinct orders in the working plan that such fellings should not be made. In his paper Glover discusses the yield calculation in various Punjab Working Plans and shows the necessity of regulating the yield not only by volume in P.B.I. but over the whole working circle. Simmons' method for his type III must therefore be applied in future working plans and the whole yield, both final and intermediate, calculated and controlled by volume at any rate above a diameter of 16”. This is further discussed in Glover's paper on “Recent changes in forest management in the coniferous forests of the Punjab Himalayas”, Punjab Forests Conference, 1931.

34. In the case of selection working circles the distribution of the growing stock in every compartment must be considered and it is a great help to draw the curve of the actual growing stock as compared to the normal or rather to a curve representing a conception of what the normal may be. The Working Plan Officer with the enumerations and the curve before him, will assess the yield of every compartment both final and intermediate. The sum of the yields for the compartments may then be compared with the total yield of the working circle calculated by Brandis and Von Mantels’s formula. It must be remembered that a correct distribution of age classes over the whole working circle does not imply a correct distribution in every compartment and this is where Brandis's method comes to grief. Glover's paper gives detailed examples of actual calculations and should be studied.
Description of Field

Most important: Outline of the 1,960-acre field is shown in Fig. 1. The challenges of working in the field are described in detail, including the need for proper planning and equipment. The field is considered to be well-suited for the crop being grown, with good soil fertility and drainage.

SECTION A

1. A table of thiamines, improved alfalfa, with a description of the crop and the results of the various modifications, should be included. The thiamines can be obtained from the list at the end of this report.

2. The yield of the crop is estimated to be 3 tons per acre, based on the average yields from previous years. The thiamines should be obtained from the list at the end of this report.

3. The results of the various modifications should be discussed in detail, including the effects on yield and quality. The thiamines should be obtained from the list at the end of this report.

4. The yield of the crop is estimated to be 3 tons per acre, based on the average yields from previous years. The thiamines should be obtained from the list at the end of this report.

5. The results of the various modifications should be discussed in detail, including the effects on yield and quality. The thiamines should be obtained from the list at the end of this report.
idea of the contents of a compartment may be obtained
from the opposite side of the valley, and this, supplement-
ed with an examination of the interior of the compartment,
will enable an adequate description to be written. In the
plains it is not sufficient to walk round the boundary of the
compartment; an entirely wrong impression of the contents
is often obtained in this way; it is absolutely necessary,
in order to obtain a just appreciation of its contents, to
traverse the compartment in at least two directions. As
the division into compartments varies with the intensity
of management, so will the description of compartments vary.
In all areas under intensive management a com-
plete description of compartment or at least a detail-
ed description of the regeneration, area is necessary.
Elsewhere as for instance, in protection working circles,
much greater latitude may be allowed, the compartments
may be bigger and the description of a general nature.
The description of compartments is entered in the com-
partment history which is the basis of the practical manage-
ment of the compartment. Descriptions should always
be written on the spot and no reliance placed on memory;
this is very important.

In case of revisions, the Working Plan Officers will
have descriptions of the previous plan to work on and those
must be brought up to date. It should be possible to cor-
relate any marked changes with the intervening history.

38. The description of compartments is carried out
under the standard headings of the texts-books as given in
the compartment history form, viz.:

Soil, situation, aspect.
Allocation to working circles.
Allocation to periods.
Description of the growing stock.
Quality class.
Enumeration results (if any).

Prescriptions of the Plan (Future treatment).
A prescribed form containing the above information, has
to be filled up.
39. The quality of crop is obtained by taking the total height and breast diameter of average dominant mature trees. With experience, crops can be assessed solely by eye, but it is necessary to check one’s estimates with hypsometer and tape. When, as often, the quality changes over a small area an average quality must be arrived at.

Density is generally judged by the eye. Only the main canopy need be considered. It is a useful check to compare enumeration results with one’s visual impressions, as regards not only density but also constitution.

40. The standard diameter classes have been prescribed in paragraph 29; their corresponding colours on the enumeration calipers are as follows:

<table>
<thead>
<tr>
<th>Species</th>
<th>0&quot;–2&quot;</th>
<th>2&quot;–3&quot;</th>
<th>3&quot;–4&quot;</th>
<th>4&quot;–5&quot;</th>
<th>5&quot;–6&quot;</th>
<th>6&quot;–7&quot;</th>
<th>7&quot;–8&quot;</th>
<th>8&quot;–9&quot;</th>
<th>9&quot;–10&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>Class</td>
<td>Chest</td>
<td>Chest</td>
<td>Chest</td>
<td>Chest</td>
<td>Chest</td>
<td>Chest</td>
<td>Chest</td>
<td>Chest</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>20&quot;–23&quot; Black</th>
<th>24&quot;–25&quot; White</th>
</tr>
</thead>
<tbody>
<tr>
<td>Painted</td>
<td>Painted</td>
</tr>
</tbody>
</table>

41. The Working Plan Officer will generally decide how many gauges are necessary. He also gives orders as to what is to be included and distinguished in the enumerations. It is being found safest, with any given species, to enumerate all but the obviously unmarketable, as these alone can be distinguished with any certainty by an officer coming to mark against the prescribed yield.

42. In enumerating shir forests where twist is a source of unfitness the degree of twist qualifying for unfitness must first be decided. This is usually fixed at 7°. But the yield should be based on fit and unfit trees combined and not on fit trees alone as the estimation of the degree or twist in a tree is liable to vary greatly, and the trees marked to make up the annual yield might be very different from the Working Plan Officer’s intentions.
43. A forest subordinate is generally put in direct charge of the enumeration work. He must be instructed to see that gangs work near each other, so far as possible, in order to facilitate control, and reduce the number of separate enumerations. He must know the boundaries of each compartment or block to be enumerated, and make them known to the supervisors. In particular he has to see that simple and experimental plots are not wrongly included in the count. He is also responsible that every man carries an efficient tool, and above all that no gang lies idle; for this the progress of enumeration must be watched and fresh work planned ahead. Enumeration books and an abstract must be forwarded to the Working Plan Officer immediately an enumeration has been completed. Ganges on the move carry their own records and are allowed a day or half-day, according to the length of march, in which to erect CHAPPARS. One empty kerosene tin per season is generally sanctioned to each gang for carrying water.

44. The Working Plan Conservator (if any, otherwise the territorial Conservator) lays down the amount of check enumeration to be done. The subordinate directly in charge usually checks 10 to 15 per cent and the Working Plan Officer another 5 per cent of the total number of trees enumerated, and up to 2 per cent difference may be passed. Ganges must never check their own work, nor should any one but the Working Plan Officer have access to the original figures. Re-enumeration should proceed in exactly the opposite direction to the enumerations, so that scribbles mark the advancing gang; these marks are then prescribed to form a cross. The number of trees found unmarked should be noted separately on the enumeration sheet. Enumerations must be carried out by quite small units and not by whole compartments. Results, of course, will finally be shown by compartments or sub-compartments, but the Working Plan Officer may often wish to sub-divide a compartment at the last moment after all enumeration work has been completed, and he will find it invaluable to have results separately for portions of the compartment. Such sub-division is also useful for subsequent checking.

45. The extent to which the growing stock is to be enumerated having been determined, it now remains to...
carry out this work. At the outset it is laid down that in
working circles organized on a periodic block system, in
which the yield is calculated by volume for the regenera-
tion area and by area elsewhere, a complete enumeration
of the regeneration area must be made. In forests where
the yield is regulated by area, no enumerations are gen-
erally necessary, but in special cases where an accurate
forecast of the probable outcome is wanted they may have
to be carried out.

46. The actual counting of the trees is done as fol-
lows: Each recorder is given a book ruled in the standard
diameter classes already mentioned, and two or at the
most three calliper men work with him. In the plains a
couple of linemen are also necessary. Starting from the
edge of the compartment a strip of forest is taken along
which the two linesmen walk tying bands of dry grass along
the line, but keeping pace with the rest of the gang. The
recorder takes up his position in the middle of the strip
and the calliper men measure at breast height and about
the species and colour of the trees on the callipers,
the recorder entering each tree with a dot under its prop-
er species and colour. After each tree has been measur-
ed it is given a spot of white paste, or the bark is marked
with a similar or light axe in the case of suitable species
like chire or deodar, to indicate that it has been recorded.

47. Another method is as follows: In addition to
his calliper, each enumerator is to be provided with (i) a
rope belt, (ii) a cigarette tin (without lid) filled with
good paste, and (iii) a bundle of some 250 pieces of
old thin paper (newspaper is most suitable) roughly 2"
square on a piece of thin wire. Nos. (ii) and (iii) are
carried on No. (i). As the recorder acknowledges the
recording of each tree measured by the enumerator the
latter tears off a piece of paper, dips it in the tin of paste
and sticks the paper on the tree at about breast
height. This will ensure that trees are not counted more than
once. For checking purposes the enumerators should be
provided with a coloured paper handle instead of white
or newspaper.

48. When the far end of the compartment or enu-
meration section is reached the line turns and measures
a strip adjacent to the one already done. The marks on
the trees counted should be placed on the side of the tree facing the direction in which the work will progress so that when working on any strip the marks on the trees of the last strip are clearly visible. In most cases a man carrying drinking water for the gang will have to be provided.

49. Wherever possible the compartment to be enumerated should be divided by clear physical features such as ridges, malls or paths into enumeration sections. The ideal section is one that can be counted in one day, so that it becomes possible for the officer responsible for the work to check the work of any one man in one day. Such check is absolutely necessary and the permissible percentage of error is a maximum of 2 per cent in number of trees counted. If this is exceeded the work of that recorder must be rejected and the man dispensed with. As a matter of fact, the percentage of error found on checking is normally less than two per cent. On completing each section or compartment the recorder hands in his results to the Working Plan Officer or the assistant in special charge of this work after signing the form. Recorders usually work in separate sections or compartments, they have, however, been concentrated in one section spread out in a long line, this was found of advantage on difficult ground as complete supervision by a responsible man was then possible. A standard day's task should be fixed by the Working Plan Officer and the work kept up to this. The custom of recording trees as sound or unsound in the enumerations has been found by past experience to be most unsatisfactory and to have served no useful purpose. Trees obviously worthless should be excised from the count, trees which fork below breast height are counted as two trees. The recorder must see that the calliper is properly applied to the hole, the rule of the calliper should touch the sora and the measurements be taken as near 4½ feet as possible, the calliper man stands on the upper side of the tree if on hilly ground, one diameter measurement suffices. Calipers must be checked from time to time. The Working Plan Officer is entirely responsible for the correctness of his enumerations and must carry out check enumerations to the extent ordered.

50. Stock-mapping will only be done when specially ordered. This subject was discussed under Item No. 15.
51. It is important that the maximum amount of
writing and typing work be done on tour, in particular
the filling in and bringing up to date of compartment forms,
the rough calculation of areas, the preparation of stock
maps, etc.

SECTION 6.

WRITING UP THE PLAN.

The standard headings.

52. The following are the standard working plan
headings.

INTRODUCTION

PART I -

Summary of facts on which the proposals are based.

CHAPTER I

The tract dealt with

Name and situation and map reference.
Configuration of the ground.
Geology, rock and soil. Climate.
Water-supply.
Distribution and area.
State of the boundaries. Legal position.
Rights and concessions.

CHAPTER II

The Forest

Composition and condition of the crop.
Injuries to which the crop is liable.
CHAPTER III
Utilization of the produce.
Agricultural customs and
wants of the population.
Markets and marketable pro-
ducts.
Lines of export.
Methods of exploitation and
their cost.
Past and current prices.

CHAPTER IV
Staff and labour supply.

CHAPTER V
Past systems of management.
General history of the
forest.
Past system of manage-
ment and their results.
Special works of im-
provement undertaken.
Past yield.
Past Revenue and Ex-
penditure.

CHAPTER VI
Statistics of growth and yield.
(To include allotment to quality classes, mean,
annual increment, current annual increment,
yield tables, etc.)

CHAPTER VII
Estimate of Capital value of
the forest.
PART II

Future management discussed and prescribed.

Chapter I.

Basis of proposals

General objects of management and brief statement of treatment required to secure them:

(a) As regards the attainment of the normal forest and the establishment of normal regeneration.

(b) As regards the silvicultural requirements of the species dealt with.

(c) As regards the yield of timber and other forest produce.

(d) As regards the improvement and regulation of the water-supply.

Methods of treatment to be adopted.

Working Circles, their area and distribution, reasons for their constitution.

Period of working plan and necessity for intermediate revision.
General constitution of the circle and character of the vegetation.

Blocks and compartment (permanent).

Analysis and valuation of the crop.

Method of treatment (exploitable size, choice of species, silvicultural system, calculation of the rotation, division into periods, allotment to periodic blocks, felling cycle, calculation of the yield).

Method of executing the fellings. Tabular statement of fellings to be made.

Subsidary silvicultural regulations (sawing, planting, weeding, cleaning, thinning and supplementary fellings).

Other regulations (grazing, protection, exercise of rights and privileges, collection and record of statistics, and control including farm record and maps as required here or generally).

(Chapters for all other working circles).
Chapter—
Miscellaneous regulations
(prescribed and suggested).

Roads and other export
works.

Improvement of water-ways
and water-supply and
methods of exploitation.

Possible development of
forest industries.

Buildings.

Maintenance of boundaries.

Surveys and maintenance of
maps.

Chapter—
Establishment and labour.

Chapter—

Financial Forecast and cost of
plan.

Chapter—

Appendices

Summary of prescription.

Only those appendices re-
quired for the check-
dition of the plan should
be printed therewith.

General prescriptions under "other regulations" in-
cluding the maintenance of control forms, records and
maps may be provided or in the chapters dealing with all
working circles generally.

Although some overlapping is difficult to avoid, this
should be reduced to a minimum. Facts and prescrip-
tions should only be dealt with in the correct place.
PART I OF THE PLAN

58. This part deals with the forests as they exist at present. The time of writing the plan, with their past history, suggestions for future work are quite out of place and must be confined to Part II. It is not always necessary to rewrite Part I completely.

54. Summarize the essential facts, the different geological formations, their position and extent, the soil produced, and more especially the effect or influence of the geology and soil on the distribution of forest types, ecology, and quality of tree growth.

55. Meteorological statistics can be obtained from the Deputy Commissioner's Office.

56. Detail separately any areas belonging to the distribution and division that are not reserved forest. Mention any important pending changes of area.

57. This particularly refers to the "legal" boundaries, i.e., divisions including interior or chark boundaries, etc.

58. Detail the (yes) notifications of all reservations only if they are few. Briefly mention resumed grants and any distinct settlements having a bearing on the existing status of the forest.

59. A clear conception of the extent and management of rights is essential both for the Working Plan Officer and subsequently for each Divisional Forest Officer very soon after taking over their duties. Give a brief resume of the rights, position, their extent, nature, etc., and a reference to the (subsequent) paragraphs of the working plan whereby they are regulated or met, and to the appendix where they are detailed or summarized.

60. Briefly specify the forest by types, mentioning only the more characteristic species; give a general description of the crop, on constitution, condition, density and age (size) of the crop. The types are to be described according to Indian Forest Records, Volume I, No. I. A new forest type can only be evolved in consultation with the Central Silviculturist, Forest Research Institute, Dehra Dun.
61. Sub-heads are arranged according to the agents causing injury. A list of areas most liable to illicit grazing is useful.

62. These are inter-dependent subjects and cannot be treated separately. There is some inevitable overlapping with "Rights and Concessions" and "Yields and the population". Avoid mentioning routes here, as they form a separate heading.

63. Include the existing grazing rates, also past rates if these have been altered during the currency of the last plan, giving brief reasons for the change.

64. This heading necessarily overlaps somewhat with "Agricultural customs of the population" and to some extent with "Methods of exploitation and their cost" to which suitable reference can be made.

65. Include here (a) methods of calculating yields, with any special local features, (b) a note on check enumerations and per cent of error found.

**PART II OF THE PLAN.**

66. This part is written largely in the imperative mood and deals expressly with the future management of the forest estate comprehended by the plan. It is, however, necessary to avoid prescriptions about purely executive matters. For example, a prescription that an area must be completely felled over in one season is permissible if it is held that a second year's fellings will endanger regeneration, but is not permissible if the object is merely to suit contractors or for any reason un-connected with the welfare of the forests. Again, the working plan must not lay down that something which requires a special order may be done with the sanction of any particular authority. It will merely say that such an act will not constitute a deviation, leaving the question of authority to the administration.

67. These are conveniently divided into:

   (i) Ideal and ultimate.

   (ii) Real and proximate:

   (a) General for the division as a whole.
(b) Particular—-or concerning different types or areas of forest.

68. Give a list of the different working circles, showing how they meet the objects of management detailed above.

69. Includes the area under rights, and summary of the "Detailed Area Statement" (Appendix I) by range and blocks showing gross and stocked areas where these are known.

70. Mention the principle followed in allotting to each P.B. and whether any excess of age classes exists. Give table showing per P.B. the gross stocked and reduced areas, and areas actually allotted (where this has been done).

71. Trees which are to count against the yield now usually comprise all marked trees of a given diameter and over of the species enumerated. Trees which are obviously unaccounted for are excluded if they have not been enumerated. It is important for the Working Plan Officer to make it quite clear exactly what is and what is not to count against the yield.

72. Give a preamble stating the object and scope of the rules. These should not be too elaborate. Marking rules will be definitely laid down in the plan by some such phrase as "The rules for markings are . . . . . . " Exceptions may, however, occur as for instance when the operation for which marking rules are being formulated is a new one and the Working Plan Officer has had no opportunity of adequately testing his rules.

73. The Working Plan Officer must be careful to prescribe for carrying on cultural operations, cleaning or other subsidiary operations rendered necessary by fellings made under the old plan, as well as under the new plan.

74. The working plan must make it quite clear whether any artificial regeneration prescribed is to be regarded as a plantation or as filling up a gap. The latter work is usually associated with filling up scattered failure in P.B. I., of a forest under concentrated regeneration. Plantations are not as a rule connected in any direct way with systems of natural regeneration. The general principle in such cases is that a plantation is a continuous area of a certain number of acres which can be mapped.
75. Other Regulations.—Insert here any regulations regarding such matters as grazing, fire protection and the exercise of rights and privileges that specially affect the circle concerned. Compare this with the heading:—

General Regulations and Recommendations, which comprises prescriptions and suggestions that embrace the whole division, e.g., petty fellings, disposal of minor produce. This regulation of rights and privileges is dealt with here.

76. All plans should state the existing grazing rates current in the division and should also note any enhancements or alterations since the last plan, recording brief reasons for it.

77. It is not up to the Block Officer to prescribe changes in establishment, but suggestions are legitimate.

78. Control and Records.—A standard prescription has to be incorporated here, though modifications may be made under proper sanction. For control forms, refer to Section 9.

II. compartment Histories—See Section 7.

Fire Records.—A record of every fire, whether accidental or intentional, but exclusive of areas burnt annually for protection of adjoining areas, will be kept in the compartment history. In all cases where only part of a compartment has been burnt a tracing of the area burnt will be attached to the compartment history, unless the Divisional Forest Officer considers that a general statement is sufficiently explanatory. These compartment histories are for record of results rather than for control; they will not be submitted for check with annual control forms, but the territorial Conservator will see that they are kept up properly.

III. Divisional Note Book.—This may be introduced in all Divisions. It is mainly a record for use of the Divisional Forest Officer, and shows a record of auction results, methods of calculating estimates of outturn of crops, results of Divisional experiments, etc. The territorial Conservator will see that this is maintained in such form and detail as he considers advisable.
79. Miscellaneous Chapter.—Mention here general matters like experiments and sample plots, which have no direct connection with ordinary divisional work, and discuss such problems as commercial grazing, and forest villages, etc.

80. The financial forecast should be forwarded to the Conservator of Forests, Working Plan Circle (if any) through the territorial Conservator, for Chief Conservator of Forest's approval before the plan is fairied out and while the Working Plan Officer is still on the spot. If the past revenue and expenditure is carefully considered in consultation with the Divisional Forest Officer, the effect of the Plan on finance should be capable of being fairly accurately estimated.

81. Summary of Prescriptions.—This is not a combined felling table for the division, but a brief resume of the prescriptions by working circles and paragraphs.

82. Appendices.—These must be kept in a minimum.

I. The first and the most essential is the area statement, with headings approximately as follows:

**THE AREA STATEMENT**

<table>
<thead>
<tr>
<th>Rate</th>
<th>Block</th>
<th>Compartment No.</th>
<th>Stocked</th>
<th>Other Species</th>
<th>Pine</th>
<th>Total gross Income</th>
<th>Timber Culm.</th>
<th>Cutting Notice</th>
<th>Other Wood Cupboard</th>
<th>Timber Working Circle</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>


II. Enumeration Results.—Figures are detailed by compartments. They should include only species counting against the yield; full detail is reserved for the compartment histories.

III. Any rules, Government Notifications or Orders.—Relating especially to the forests (or part of the forests) of the division.

IV. Statement of Rights.—The amount of detail required will vary in different divisions.

33. Correct method of arranging and writing the Plan.—Pages and paragraphs are numbered from the beginning of Chapter I and both form a consecutive series through parts I and II of the Plan. The pages of the appendix are numbered separately. Paragraphs and not page numbers should be mentioned in cross references; remember, too, that the manuscript pages will not correspond to the printed pages.

Note also the following miscellaneous points:

(i) Type in block capitals any passage to be printed in "bold face"; such as e.g., the prescription fixing the yield in units. This advice must be used sparingly, or its effect will be lost.

(ii) Words to be printed in italics must be underlined by the typist.

(iii) Writing must be clear and concise. Avoid redundancy and the word "etc." As the preparation of the plan proceeds it will be the duty of the Working Plan Officer to obtain the approval of the territorial Conservator and the Deputy Commissioner or Collector to any recommendations or prescriptions in his plan with which the Deputy Commissioner might subsequently have to deal. For instance, any modification of facilities to concessionists or any restriction to right-holders or concessionists due to anticipated closures. Here all suggestions or prescriptions even remotely affecting the local villagers must receive Deputy Commissioner's approval before the plan is submitted.
The name of the working circle must be typed in full on the top right hand corner of each page of the draft chapters in Part II which deal with definite working circles.

84. If required this will be written by Conservator Forests, Working Plans and if there be none by the territorial Conservators.

85. This is to be an alphabetical list of vernacular, Glossary and technical terms. Names used in the plan which may conveniently be classified under "botanical", and "miscellaneous" headings. The vernacular names have to be followed on the page on which they first appear by the Latin equivalents in which they may appear by the Latin equivalents in brackets; the spelling of the botanical names of plants or flowers should be adopted. All vernacular names not beginning with a capital letter are to be printed in Roman characters without a capital (e.g., silver fir, oak). Vernacular names which have become widely known and used in the English language may also be printed in Roman characters without a capital, such as the names of trees, shrubs, and flowers. All technical terms will be defined in the "Glossary of technical terms for use in Indian Forestry." Indian Forest Records, Volume XV, Part II.

86. These should be included wherever terms are "technical" used and the meaning of which has not been established as e.g., "regeneration", "reproduction".

87. There is a general tendency to adopt capitals unnecessarily. The following are examples indicating where they are used and are not required:

- Ambala District,
- Kangra Division,
- Regular Working Circle,
- Miscellaneous Working Circle,
- Divisional Officer,
- Range Officer,
- Selection system,
- Periodic block,
- Working circle,

though if any of the above is used as a heading by itself each word would be a capital.
88. In writing the working plan although a certain amount of overlap is unavoidable care must be taken to see that facts are not supplied at the wrong places. It is advisable for the Working Plan Officer to submit the final draft of his plan by chapters as soon as they are complete. These should be accompanied by a short explanatory note stressing any points of importance and drawing the attention of the Working Plan Conservator (if any otherwise the territorial Conservator), to any deviation, however slight, from the preliminary working plan report or subsequent instructions.

89. A single typed copy will first be made and after passing by the Working Plans Conservator (if any otherwise the territorial Conservator), two final copies will be typed. The Working Plan Officer must check at least one of these himself and initial each page at the top right hand corner after necessary corrections. Every sheet of the final draft, corrected from the master 'copy' must be similarly attested by the Working Plan Officer. The Working Plan Officer will submit these two copies (including the original) to the Conservator, Working Plans (if any otherwise the territorial Conservator). The original will eventually go to the Press and the other one will be used by the Conservator of Forests, Working Plans Circle (if any otherwise the territorial Conservator), in his office until printed copies are available.

90. The Working Plan Officer is responsible for the correctness of all calculations, details, area statements, descriptions, and figures, etc., given in the working plan. The Working Plan Conservator (if any otherwise the territorial Conservator) will supervise the main structure and important prescriptions of the plan. He will correct and amend them at his discretion. When the master copy of the plan is complete it will be forwarded to the Chief Conservator of Forests for his approval. Afterwards the civil authorities will be addressed under paragraph 766(7) of the Land Administration Manual for countersignature and return of the plan to the Working Plan Conservator (or territorial Conservator if there be no Working Plan Conservator) for taking steps for printing and obtaining Government sanction. Sufficient copies
of the first proof will be obtained from the press for the Range Officers concerned to work on before final copies are received. This will be necessary only if the final printing of the plan is likely to be delayed beyond the date from which it is to be brought into force. One copy of the proof is to be sent to the author for check and return to the Press through the Working Plans Conservor (or the territorial Conservor).

91. In the Deputy Secretary to Government, Punjab’s letter No. 2396/44, dated the 18th August, 1944, the Chief Conservor of Forests has been authorized to sanction all working plans for the Soil Conservation Circles. He may, however, refer to Government any working plan, in which any question of principle or special interest is involved. All other plans require the sanction of Government.

92. Once a plan is sanctioned, its provisions must be carried out until it is revised or amended by the Chief Conservor of Forests. Interim amendments of the plan, very often made without thought or due consideration of the results of such amendment, have in the past resulted in much harm and such proposals are to be discouraged.

Section 7.

Compartments Histories

93. The compartment history or forest journal is a record of the past and present history of the Forest. The Forest Journal

...
ordinarily contain the following essential information, which may, however, be modified to suit the special requirements of a working plan:

(i) A tracing of the 4'-1 mile forest survey map of the compartment or forest or block of forests concerned i.e., for the unit for which compartment history or forest journal is prepared.

(ii) A tracing of the stock map for the compartment forest, or block of forests concerned.

(iii) A complete description of each forest or compartment under the standard headings, viz—

1. Situation, elevation, aspect, slope, soil, allotment to working circle and area.

2. Description of the growing stock, locality, quality class, details of enumeration and working plan prescriptions.

3. Communications and fire conservancy proposals, miscellaneous notes on timber, and grazing rights, carrier routes and rates, etc. etc.

4. A brief record of the past history of the crop bearing on the management and improvement of the forest.

And as work proceeds:

(v) Useful notes on marking, seed years, observations on the progress of regeneration both natural and artificial, suitability or otherwise of the prescribed system of management, outbreaks of fires and other noteworthy occurrences.

(vi) Statement of trees felled and materials extracted annually by all agencies (Forest Journals, Exploitation Control Forms A and B).

(vii) Statements showing year by year progress of regeneration with details of silvicultural operations such as debris clearing and burning.
94. Compartment histories or forest journals form an integral part of the system of control. They will be prepared or revised by the Working Plan Officer in duplicate sets for the use of the Range Officer, and the other for the Divisional Forest Officer.

The Range Officer’s copy is intended for use in the field, and will be the working copy in which the Range Officer and gazetted Inspecting Officers will record their observations and notes. At the close of every year the Range Officer will send his set of compartment histories to his Divisional Officer, who will edit and consolidate all the annual notes and observations, typed copies of which will replace the originals and will be filled both in the range and divisional compartment histories or forest journals.

All notes shall be brief and concise and shall be signed and dated.

95. Marking Officers will consult the respective compartment history files before commencing marking any compartment, and at the close of marking, they will invariably make a note in the file detailing the lines on which marking has been done.

96. At the time of office inspection, Divisional Forest Officers and territorial Conservators will report on the upkeep and posting to date of compartment history files or forest journals. Officers taking over charge of a range or division will give a receipt for these records.

97. All compartment history files will be posted to date accurately before divisional annual control forms are prepared. To ensure this, Divisional Officers will submit the following certificates to their Conservators with the control forms:

"Certified that I have personally satisfied myself that all compartment history files or forest..."
journals are fully and accurately posted to date, and that the annual control forms for the year agree with the entries in the compartment histories or forest journals.

Section 8.

Maps:

39. In addition to the 1" = 1 mile management map, two complete sets of 4" = 1 mile scale forest survey maps, folded to pocket size 9" x 6" showing division into compartments, sub-compartments, enumeration sections, and annual coupes, etc., and where necessary, coloured to show allotment to working circles, periodic blocks, felling series, etc., will be prepared by the Working Plan Officer. One set will be for the use of the Divisional Forest Officer and the other set for the use of the Range Officer. The range copy of the map will be the working copy. It will be kept posted to date, all new roads and paths, changes in the forest boundaries are to be shown on, etc., etc., being inserted therein as they occur. The divisional copy will be brought to date at the close of each year.

40. At the time of office inspection, Divisional Forest Officer and Conservators will report on the proper upkeep and posting to date of the management maps.

Section 9.

Control Forms:

100. Annual control forms consist of specially prepared forms showing the prescriptions and suggestions of a sanctioned working plan or working scheme, and the fellings and other exploitation actually made or the working actually carried out against them. It must, however, be clearly understood that control forms are concerned only with the control of prescriptions and suggestions. They are not account forms and so they will not be encumbered with unnecessary details of petty fellings, set cuttings, methods of exploitation, re-planting operations, extensive information regarding repairs to communications, buildings boundary pillars and fire lines, sowing, planting, and other cultural operations, etc.
101. Two control forms will be maintained:—

(i) Control Form Nos. 2, 2-A or 2-B which control fellings and other exploitation, and

(ii) Control Forms Nos. 4 and C which control works of improvement and re-production.

The old control forms 2 and 4 generally meet the requirement of simple working plan but they do not suit the special needs of modern plans and in consequence forms 2-A and 2-B have been designed. The old control forms suggested will, therefore, be either modified by the Working Plan Officer, or special forms will be prepared by him to suit the special needs of a particular working plan or working scheme.

Annual Control Form Nos. 2, 2-A and 2-B.

102. Their specific objects are:—

(i) To compare the actual fellings or other exploitation of the year with the working plan or working scheme prescriptions, and to enable the controlling authority to see how far the provisions of a sanctioned plan as regards fellings have been carried out and where they have been departed from.

(ii) To enable the Divisional Forest Officers to ascertain at the beginning of each year what area or advance falling or other matters have to be adjusted in the current year.

103. The following rules apply to the preparation of control forms:—

1. Separate control forms will be prepared for the main regeneration selection, etc., and subsidiary (Thinning and Improvements) fellings.

2. Control Form Nos. 2, 2-A or 2-B will be prepared by Working Circles, using separate sheets for each Working Circle.
3. All entries in control form No. 3, 2-A or 2-B will be made under the following three main heads:

(i) Prescriptions of the Working Plan.
(ii) Suggestions of the Working Plan.
(iii) Neither prescribed nor suggested in the Working Plan.

104. For the sake of convenience, the headings of control form No. 3 (P.D. Code Sample) are defined as under:

Columns 1 to 6 - Control columns.
Columns 7 to 11 - Result columns.
Column 12 - Deviation column.
Columns 13 to 17 - Outcome columns (which will be filled in only in special cases).
Column 17 - Remarks or explanation column.

The actual method of entry will vary with the methods of control.

(a) When the control is by volume or number of trees, the method of entry will be as follows:

Control columns 1—6. The first entry will be in red ink, and will show the deviation (+ or -) if any, brought forward from column 12 of the previous year. Column 1 will show the year from which carried forward; columns 2-4 the periodic block or forest and column 6 the volume or number of trees. The second entry will be the prescription for the year; it will be made in black ink and will be arranged as the first entry. The figures in column 6 will then be adjusted by addition or
subtraction to show the column or number of trees removale during the year.

Results, columns 7—11. Column 7 will show the year of working, i.e., the year for which the control form is prepared. Columns 8, 9, 10 will show the forest, compartments or sub-compartments in which work has taken place with their areas. Column 11 will show the number of trees by species (controlled) and classes (controlled) with their gross volume (calculated using the same volume factors as used for the calculation of the yield), removed from each compartment or sub-compartment. The entries will then be totalled below. Column 11 for this purpose be enlarged and sub-divided as required.

Deviation Column 12. This will show the difference in volume or number of trees between the totals of columns 6 and 11.

Remarks column 17. This will explain deviation, and give authority for the same if it is outside the limit prescribed in the working plan.

(b) When the control is by area, the method of entry will be as follows:

Control Columns 1—6. (i) All deviations (+ or —) carried forward from deviation column 12 of the previous year will first be entered in red ink. Column 1 will show the year of the prescription, columns 2—4 the corresponding forest and compartment with gross area and column 5 the net area prescribed for operation.

(ii) The prescription of the year omitting any entry already made above will then be entered in black ink; the arrangement to be the same as above.

(iii) Advance felling undertaken during the year will then be entered in black ink; the arrangement to be the same as above.
Results columns 7 to 11. Column 7 will show the year of working. Columns 8, 9 and 10 will be filled in only if the prescription has been completely carried out.

Column 11 should be filled in showing the number of trees and their gross volume removed from each compartment or sub-compartment with details of species and classes, for which purpose this column will be suitably enlarged and sub-divided.

Note—It is true that in cases where the yield is regulated by area, the area fallen over is the important entry, but with a view to enable the controlling officer to know what sort of felling has actually been done, and a list of trees noted by species and classes is necessary.

Deviation column 12. Will show the plus or minus deviation with the name and number of the forest and compartment, and its area.

Remarks column 17. Will explain clearly the deviations.

Note. (i) As explained above, columns 9, 10 and 11 will only be filled in when the work has been completed. For instance, an area graded for thinning should not be shown as worked off until all trees marked in it for felling have actually been felled. In cases where trees are reserved for light cutting, a remark to this effect should be given, and the area struck off. The trees actually marked must be shown in the form.

(ii) Similarly, if a compartment has been gone over for bicycles, it should be shown as worked off even if no trees have been cut on account of the area being already open, a remark to this effect being made in column 17.

(iii) In the case of an advance letting, if the prescription has been fully carried out, it will be shown as a plus entry in deviation column 12, but if the letting remains incomplete, it will be shown as a minus entry in column 13. In the following year, it will be shown as minus in red ink in column 1—9 and if completed, it will be shown in column 10, 11 and 12 and a plus entry will be made in the deviation column 13, in subsequent years, it will continue to be shown in red ink in columns 1—4, and as a plus in column 13 with the remarks in column 11 that the prescription was carried out in each and every year, till exclusive of the year of prescription, when the entry will automatically disappear. For example, an 1893-94 prescription carried out in 1893-94 will be shown as a plus entry in the 1923-24 return, if completed in that year, and a minus entry in 1894-95 and 1895-96, and a plus entry will be made in column 12 where it will continue as a plus entry till 1896-97 when it will automatically disappear.
105. The paragraphs of the working plan or scheme should be quoted under the year or period of prescription (column 1), nature of fellings to be made (column 5), and area or number of trees or quantity of material to be exploited (column 6).

106. Against trees removed, the agency of removal should be quoted as under:

- Government agency
- Purchasers
- Free grantees
- Right holders

107. In working circles with a volume regulation factor, the same volume factor will be used for the calculation of the volume felled as for the calculation of the prescribed yield.

108. Trees of species and diameter classes not under control, when felled in areas under volume or number of trees control, will not be shown in control form No. 2. For example, if only deodar and kail down to 8" diameter are included in the calculation of the yield, only deodar and kail trees of 8" and above in diameter will be included in the total of the trees felled against the prescribed yield and shown in control form No. 2; trees of other species or deodar and kail trees under 8" diameter, though included in the annual marking list, will not count against the prescribed yield and so will not be entered in control form No. 2.

109. Working plans permit the removal of odd dry Petty Pines, trees, trees put on road work, trees required for departmental use, right-holders, free grantees, etc., etc., at the discretion of the Divisional Forest Officer. They are not silvicultural fellings and as such they do not affect the working plan control, they should not be entered in control form No. 2 except when they happen to occur in an area under volume or number of trees control. Similarly, a few odd trees felled for right-holders and free grantees, etc., under thinnings or improvement fellings, does not
mean that the area has been gone over for thinning or improvement fellings, and the area in such cases should not be entered in control form No. 2 as operated upon against working plan prescriptions.

110. In areas covered by working plans or sanctioned working scheme no fellings not authorized under the working plan or working scheme will be carried out for any purpose whatever without the previous sanction in writing of the Chief Conservator of Forests, Divisional Forest Officers contemplating any such fellings will send up a proper case for sanction through their Conserving Officers before any markings are carried out. All trees so felled will be entered in control form No. 2 under the heading "Fellings neither prescribed nor suggested in the Working Plan" and the sanction authorizing such felling will be quoted. The territorial conservators will submit such propositions to the Chief Conservator of Forests through the Working Plans Conservator (if any).

111. No felling for other purpose whatever except—

(1) satisfaction of rights,

(2) meeting of departmental requirements,

(3) meeting of petty demands from other Government Departments, will be made from areas not covered by working plans or sanctioned working schemes, without the previous sanction in writing of the Chief Conservator of Forests. Conservators may authorize such fellings to the extent covered by such free grants as they themselves have powers to sanction. All trees so felled will be entered in control form No. 2 under the heading "Fellings neither prescribed nor suggested in the Working Plan."

112. (a) No trees for export will be marked in the III class forest or the forests of the Unregulated Working Circle without the previous sanction of the Chief Conservator of Forests. All trees so felled will be entered in control form No. 2 in Working Plan under the heading "Felling neither prescribed nor suggested in the Working Plan."
(b) No mature trees will be felled in so-called supplementary or subsidiary fellings in forests of the Regular Working Circle outside P. B. I. unless definitely prescribed in working plan.

(c) No tall trees required for the use of right-holders will be felled for export.

113. Divisional Forest Officers are strictly forbidden to make extra or advance fellings not sanctioned or contemplated by working plans or sanctioned working schemes without obtaining previous sanction of the Chief Conservator. These sanctions will be quoted in the remarks column of Control Form No. 2.

114. All other deviations from the prescriptions of a working plan sanctioned working scheme, e.g., deficit fellings, alteration of the year of felling, writing off or abandonment of arrear fellings, etc., will be sanctioned by Conservators. Sanctions for such deviations should be obtained and quoted in the remarks column of Control Form No. 2.

Before approving any deviations from the prescriptions of the Working Plan or scheme as contemplated in paragraphs 113 and 114 above, the territorial Conservators will invariably obtain previous concurrence of the Working Plans Conservator (if any) to the same and quote his authority in support of the deviation in the remarks column of the Deviation Statement when it is submitted to the Chief Conservator along with the Control Forms annually for approval. A copy of the deviation statement so submitted to the Chief Conservator will also be supplied to the Working Plans Conservator (if any) side by side for record in his office.

115. Sanction to deficit fellings against the working plan prescriptions should be renewed every year until the fellings are carried out or written off. No sanction to a minus entry is, however, required until the end of the period in cases where the yield control is periodic and not annual.

116. Any entry brought forward from the previous year, if written off or abandoned from the years
control form No. 2, must be supported by the sanction of the Conservator, together with a justification for not carrying out the working plan prescription.

117. Annual control forms 4 and C deal with a record of all works carried out in connection with the construction and repair of communications and buildings, demarcation, fire-protection and cultural operations such as debris burning, planting, fencing, weeding, cleanings and improvements. It must, however, be again emphasised that this form is not an account form, but a form designed merely to control works of maintenance, reproduction, improvement and protection prescribed or suggested in a working plan and actually carried out. Details, therefore, are not wanted in control form No. 4, but only an abstract of work done with expenditure incurred. All petty items not affecting the plan and all unnecessary information will be rigidly excluded from this form.

2. Control form No. 4 suggested in the Forest Department Code, 7th edition (Appendix II), will be used after the following slight modification of the headings for all works except cultural operations:

Column 1—For “locality” read “year”.
Column 2—For “description of work” read “prescription”.

A specially prepared form called control form C which is an abstraction of the Forest Journal form C will be used to show the progress of regeneration and cultural operations carried out in a year during the year.

118. Form C will be prepared by working circles, i.e., separate sheets will be issued for each working circle, form 4 for all other works will be prepared for each working plan area.

119. Form 4 will be divided into the following 3 main heads:

I. Prescriptions of the working plan.
II. Suggestions of the working plan.
III. Neither prescribed nor suggested in the working plan.
120. The entries will be made by budget sub-heads as under, so as to facilitate totalling of each sub-head. The nature of the work and the working plan paragraph authorizing the operation will be the main heading e.g.,

B. V. a—

(i) Construction of new buildings (paragraph 50).
(ii) Repairs to buildings (paragraph 55).

B. IV. a. Construction and repairs of boundary pillars and clearance of boundary lines. The perimeter of boundaries (a) checked and (b) repaired, with total expenditure (no details), to be shown against the total perimeter of boundaries in the working plan area. Where, however, quinquennial boundary check is prescribed by forest, the names of the forests to be checked and actually checked should be entered.

B. IV. c. Departmental firing. The total area burnt departmentally against the working plan prescriptions with costs, separately for (1) P. B. L. and (2) other P. B. 's and the total length of line cleared against the total length of line and fire traces with costs (no details).

B. V. c. Construction of new Roads|Paths|Bridges to be shown separately against the working plan programme of roads and paths with total cost of each project, but no details.

(ii) Repairs to Roads|Paths|Bridges separately, the total length of Roads|Paths repaired with total cost and average cost per mile.

B. V. b-(1) Construction of new buildings. (as per roads).

(ii) Repairs to buildings—the number of buildings of different types repaired with total expenditure on each type to be shown against the number of buildings of each type in existence.

B. V. c. Maintenance of compounds.

121. A consolidated statement of all deviations from a working plan or sanctioned working scheme will be prepared and submitted by the Divisional Forest Officer along with his annual control forms.
122. All control forms will be prepared for the financial year.

2. At the beginning of the year Divisional Forest Officer will prepare manuscript Control Forms bringing forward the areas, noting the advance fellings and adding the prescriptions of the year. As the works proceed appropriate entries will be made every month so that the position is ascertainable at all times of the year. The divisional annual control forms will be prepared by the Head Clarke, but the Divisional Forest Officer is absolutely responsible for the correctness of all details of volume felled, for the deviation statement and its explanation. Such futile explanations as “not done for want of plant” will not be accepted.

3. The divisional annual control forms will be submitted to the Conservator so as to reach his office by the 15th May at the latest together with (i) a deviation statement (ii) a certificate to the effect that all compartment histories are fully and accurately posted to date and the annual control forms for the year agree with the entries in the compartment histories, (iii) a note on the progress of operations prescribed in the working plan,

—vide Chief Conservator of Forests’ letter No. C-175, dated 8th December, 1930, and (iv) report on closed areas,—vide Chief Conservator’s letter No. 2563, dated 30th September, 1931.

Audit Orders.

123. The check of annual control forms is a very important work and must not be neglected. Being it is the basis of office control of all forest fellings and works. The following orders are issued for the audit of annual control forms:

1. The control of working plan prescriptions lies with the territorial Conservators who are responsible for the scrutiny of their annual control forms especially in their technical and working plan aspect.

2. The Conservators Superintendents will maintain a register wherein he will show the date of the receipt of the divisional annual control forms date of the commencement of their check, date of the issue of objection memorandums, date of their receipt back from the Divisional
Forest Officer, date of the submission of control forms to the Conservator and the Chief Conservator of Forests, and the duty of their final return to the Divisional Forest Office. He will issue reminders, if control forms are not received on due date, and if objection means are not received back with reply within one month of the date of issue.

3. Before commencing the check of control forms pertaining to any working plan, the incumbent concerned in the Conservator Office will read very carefully the working plan concerned, and understand it, especially its chapter on "Control" which deals with the special needs of the working plan as regards the control of its prescriptions, etc. He will thoroughly acquaint himself with the general orders on the preparation of control forms and follow them in so far as they are compatible with the orders given in the chapter on "Control" in the working plan. He will study and understand sample control forms prepared by the Working Plan Officer.

4. The Control forms will then be subjected to detailed examination and check. He will first see that the control forms are compiled in accordance with the general instructions issued and the sample control forms prepared for the working plan. He will then satisfy himself that the excesses and deficits are correctly brought forward from the previous year's forms, that the working plan prescriptions are duly filled in, that the red and black entries are properly made, and correct paragraphs are quoted. He will also see that the same diameter classes and the same volume factors are used as for the yield calculations and otherwise check all volume details. He will see that sanctions of the competent authorities are quoted against all advance, excess or deficit fellings and that the reasons for deviations are sufficient and clear.

5. After detailed examination and check, the Clerk concerned will issue a consolidated objection memo, wherein he will bring to the notice of the Conservator glaring departures from the working plan prescriptions and irregularities in the methods of preparation and general orders on the preparation of control forms contained
In this Chapter. He will particularly point out the excessive and deficits and other important deviations insufficiently explained or not supported by sanctions of the competent authority.

6. On receipt of the control forms and the objection memo, the Conservator will scrutinize the control forms in all respects and pass orders on the objection memo, which will then be issued to the Divisional Forest Officer under the Conservator's signature.

7. When all objections have been settled, the Clerk concerned will put up the control forms and deviation statement with other enclosures, duly checked and corrected, to the Conservator who will pass and countersign the control forms and deviation statement and submit them to the Chief Conservator of Forests along with any remarks he may wish to make.

8. When they have been finally approved by the Chief Conservator of Forests, control forms and the deviation statement will be sent to the Divisional Forest Officer who will keep copies of the control forms in bound registers, maintained separately for each working circle.

9. The divisional control form registers will be a permanent official record and will be carefully kept in the divisional office and seen by the territorial Conservators at office inspection.

Instructions regarding control forms for Working Plan. In view of the varying needs of different working plans, it is impossible to standardize annual control forms and the methods of their preparations. The exact nature of the forms and the methods of entries to be made therein will, therefore, be dealt in detail by the working Plan Officer in a separate chapter of the working plan devoted to "Control". In doing so he will keep in view the forms suggested in the old Forest Department Code and the modified forms already in existence and the general orders issued in this order on the preparation of control forms.

2. The Working Plan Officer will prescribe and prepare sample control forms separately for each working circle, showing exactly how control is to be effected when the working plan comes into force. The sample control forms will be printed as an appendix to the plan.
§ In the "Control" chapter of the working plan, the Working Plan Officer will clearly distinguish the prescriptions of the plan from the suggestions and give a summary of the prescriptions followed by a summary of the suggestions separately for each working circle except for miscellaneous regulations such as roads and buildings and repairs which are common to all working circles. A tabular statement will be prepared giving this information along with reference to relevant paragraphs of the plan.

Section—10

MISCELLANEOUS

125. The Working Plan Officers should write Progress reports their monthly progress reports in the form below and send a copy of the same to their Conservators on the 5th of each month:

(i) Progress of Inspection of Forests with a view to writing out description of compartments, formation of working circles and falling series, proposals for future treatment, etc.

(ii) Progress of Enumeration work.

(iii) Checking of Enumeration by the Working Plan Officer himself. Results of checking must invariably be noted in each case.

(iv) Progress of Ring Counting.

(v) Progress of collection of other statistical data.

(vi) Progress in the preparation of stock and Management (Working Plan) maps.

(vii) Progress in actual writing out of the working plan.

(viii) Miscellaneous.

126. The Working Plan Officers shall intimate annually their consolidated requirements of stationery direct to the Conservator of Forests concerned who will meet such demands.
127. Normally the scale of tents prescribed will be as follows:

For Working Plan Officer.

<table>
<thead>
<tr>
<th>Description</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mess deck tent</td>
<td>5' x 5'</td>
</tr>
<tr>
<td>2. Mess deck tent</td>
<td>5' x 6'</td>
</tr>
<tr>
<td>3. Shoulder tent</td>
<td>10' x 10'</td>
</tr>
</tbody>
</table>

*Note.* All tents and shoulder shall be provided with sotirahs and they should always be in their containers for transport. The tent poles in all cases should be cut and fitted with iron sockets for joints.

128. It is essential that the camp clerk and the attached ranger have a table and a chair each. The following scale is followed:

For Working Plan Officer.

- 2 folding tables and 2 folding chairs.

For Camp Clerk.

- 1 folding table and 1 folding chair.

For attached Ranger or Deputy Ranger.

- 1 folding table and 1 folding chair.

In addition to the above the following stock articles will also be needed for the Working Plan Officers and this staff:

- Portable typewriter one.
- Cash box for camp clerk.
- Yakdans as required, with locks.
- Cash bag, cotton or leather.
129. These are, generally procured from the divisional stock and forest dispensaries, if any, available. The Divisional Forest Officers will arrange to stock sufficient medicines for the Working Plan Officers well before the Working Plan is taken up, so that they are in a position to supply the medicines on demand by the Working Plan Officers.

130. The tendency amongst the Working Plan Officers to leave their work and ask for permission to come to the headquarters to discuss various points should be discouraged. Most of these questions can be decided when the Conservator is on tour or at the point at issue can be discussed during the slack months when Working Plan Officers are writing up their plans.

As the preparation of the plan proceeds the Working Plan Officers will take the opportunity of discussing with Deputy Commissioners or the Canal Executive Engineers as the case may be, the proposals for future management embodied in the plans so that no subsequent objections be raised to the recommendations or prescriptions of the plans with which Deputy Commissioners or the Executive Engineers may have to deal.

131. All petty afforestation schemes for areas required under Section 53 of the Indian Forest Act or under Chas Act, etc., etc., will be drawn up by the territorial Divisional Forest Officers themselves.

132. Vide correspondence relating with Chief Conservator of Forests No. 3529, dated 30th March, 1947, it has been decided that in future all working plans will be printed and published in one standard size i.e., 9.5" x 7.2".
TECHNICAL ORDER NO. 12

THE STORAGE OF EXPLOSIVES AND METHODS OF BLASTING

The explosives used in the Forest Department are blasting powders and dynamite (or gelignite). The storage of explosives is controlled by the Indian Explosives Act, 1884 and the Explosive Rules, 1940. Each Forest Division and Range must possess this Act and the Rules. Every Divisional Forest Officer and every Range Officer should go through them very carefully and the instructions given must be followed. Licenses should always be procured for the storage of gunpowder and applications for such licenses whenever necessary should be submitted to the Inspector of Explosives, North Circle, Agra. The following general instructions are, however, given which should be strictly followed and Divisional Forest Officers and Conservators should ensure during office inspections that these instructions and orders in the Act and Rules are being acted upon.

1. (1) On no account whatever is dynamite or any explosive to be stored in godowns attached to rest-houses or to any other dwelling house.

(2) Dynamite and gunpowder should be stored in a special godown situated at least 200 yards from any dwelling house. The godown should be fenced and not exposed to great heat or great cold. It is a good thing to cover the godown with earth to maintain an equable temperature.

(3) No iron may be stored in the explosive godown.

(4) Detonators must be kept separately and must not be stored in the same place with dynamite.

(5) The key of the explosive godown must be kept by the Range Officer, especially as villagers of hill divisions are likely to steal gunpowder at the first opportunity.
B.—When at works.

(6) Dynamite should not be exposed to the sun as, if heated above 100° F., it is liable to explode by concussion.

(7) Care should be taken when the temperature is low, as dynamite when cooled down below 40° F., explodes very easily by concussion.

(8) Dynamite and detonators must not be kept together when not in position for firing.

(9) Explosives should never be entrusted to a workman or a coolie, the officer-in-charge of the work must always keep them in his own personal charge. Under no circumstances should explosives be stored where subordinates live or where fires are lighted.

(10) While on works explosives must be kept under lock and key in small separate wooden boxes; a temporary magazine must be built wherever large works are in progress. One room to be set aside for fuse; and detonators and another for dynamite and gun-powder.

(11) Where there is danger from forest fires the ground must be kept clear of all inflammable material to a distance of 20 yards all round the magazine.

TRANSPORT

3. Detonators must never be transported at the same time as dynamite. Detonators must always be very carefully handled. Any kind of explosive when in transit must be accompanied by a Forester. In no case should the transport be allowed through public places and streets or a special permit has to be obtained.

3. Blasting powder should be used only for blasting soft rocks, such as sandstone or for obtaining stone for building.

Dynamite or gelignite is usually used for the harder rocks, such as schists and gneissess met with in the construction of roads.
4. The standard breadth of the blast hole is 2" (the
diameter of the jumper used by the Forest Department is
1½") and the depth according to the size of the rock to be
blasted, usually from 1 foot to 3 feet. The blast-hole
should always be drilled at right angles to the rock strata
and should always be placed in sound rock without cracks.
Pillars and crevices in rocks to be blasted must be care-
fully avoided so that the charge is not nearer than 1 foot
to a crack.

THE CHARGE.

5. Usually a handful of blasting powder or one dyna-
mite cartridge 'for every foot of depth of blast hole, but
more should be used when specially hard or large rocks
are to be blasted. In case of doubt, a charge should al-
ways be too large rather than too small.

LOADING THE BLAST HOLE.

AX—With dynamite.

6. It is usually better to do blasting in the summer,
as then the dynamite is in a fit condition to put the de-
tonator in, without first warming the dynamite. Whereas
in winter the dynamite is so hard that it is impossible to
put the detonator in it without first softening it by bat-
ing it in a special case or in the trousers pocket and never
before a fire.

7. If more than one cartridge is used, the lower
cartridge should be broken into pieces and gently rammed
down. A hole should be made in the top cartridge about
the length of the detonator (1½") and rather wider than
its diameter and the detonator gently pushed into it. Be-
fore the detonator is connected to the dynamite, the
fuse should be put into the detonator so that it
cannot come out. If the detonator is pushed too far into
the cartridge, the fuse may set fire to the latter before the
explosion of the detonator and loss of power with
dangerous fumes will be the consequence. If the decono-
tator is to be used in damp places or under water, the jun-
tion must be made water tight with grease or tar. The
dynamite, detonator and fuse now being all connected,
the dynamite should be gently lowered into the hole.
The rest of the hole should be filled up with earth; pour in the earth gently at first, but the top layers may be rammed fairly hard. The mouth of the hole must be tightly rammed with clay care being taken that the fuse is not cut. Note that the ramming must never be done with iron; use the tamping bars supplied for the purpose, which have a brass end. Failing special tamping bars wooden handles must be used. The length of the fuse to be used depends on the place being blasted; if there is no cover near at hand and the "get away" is difficult, a long length of fuse must be used. There is never anything to be gained by using a short length of fuse.

B.—With blasting powder

8. The gun-powder is poured in, with the fuse inserted and tamped gently; above the gun-powder a wad of dry earth or sand is packed tight with a special brass or copper tampering bar or wooden handle. When water finds its way into the bore hole it must be dried with quick lime and the powder will then be poured into the hole by a funnel or a tube.

PRECAUTIONS.

9. If blasting operations are being carried out near a road, traffic must be stopped until the "all clear" signal is given. More blast than the number actually required results in considerable loss of explosives and sometimes in accidents. It is safer to fire the number of blasts to be exploded beforehand as it has in practice been found impossible to take a complete account of what number, if any, have failed to fire when too many are fired at one time.

10. If more than one blast is being fired at a time great care must be taken to notice if all have gone off before returning to the site. If a blast does not explode the greatest care must be taken. It is safest to avoid the spot for some hours and then drill a separate hole and explode the second charge. The fresh hole must be bored not less than 8" from the old one and loaded and fired in the usual way. The explosion in the new hole will nearly always explode the first charge. Should the first hole be of considerable depth, it will be necessary to make the
new hole 6" lower than the top of the dynamite in the old hole. If gunpowder is being used for blasting and the charge does not explode the hole should be filled with water, left for 24 hours and then a fresh hole drilled and exploded. Men have been blinded by pulling out fuses thought erroneously to be extinct.

11. Don't drop dynamite in cold weather. Don't leave it in the sun. Don't warm it at a fire, special hot water cans are provided. Don't leave dynamite and detonators together. Don't carry detonators in the waistcoat pocket and drop them in a fire. Don't pull out the fuse from an unexploded charge for several hours. Don't use iron jumpers for tamping.
TECHNICAL ORDER NO. 13.

Resin Tapping Instructions and Rules.

Section 1.—Introductory.

From time to time instructions and rules have been issued on resin tapping both in Working Plans and other places. They were last issued as Punjab Forest Leaflet No. 13. This technical order is intended to replace all previous orders and to standardise all resin operations.

Section 2.—General Considerations.

2. In the Punjab, resin can be obtained from Pinus roxburghii (long leaved pine: Vern: Chir, Chill), from Pinus Excelsa (blue pine: Vern: Kall, Bier) and from Pinus Gerardiana (Gerard's pine: Vern: chiagoza, nasua). Gerard's pine is found in the remote tracts of the inner Himalayas lying beyond the influence of the south-west monsoon and cannot be economically tapped for resin. The blue pine produces a turpentine of simple construction and high quality and a resin with a high percentage of the higher grades, but the forests are generally so remote and grow at elevations where the tapping season is so short that it has not hitherto been possible to tap this pine. At present, however, the resin industry in the Punjab is entirely dependent upon the long leaved pine. At present, the principal sources of supply are the Government and other forests of the Kangra and Himachal. Tapping is extensively done in Himachal and Pepsu.

3. Members of the controlling and superior executive staff are expected to be acquainted with the structure of the wood of Pinus roxburghii and the distribution of the resin vessels therein and to make themselves acquainted with the latest information on the subject. The bibliography printed at the end of this leaflet gives a list of the more important publications. A concise summary of the history of the Indian resin industry, taken from the pamphlet, "The work of the Forest Department in India" (1929) and from information furnished by the Manager of Jalle Resin Works, forms Appendix I of these Instructions. This appendix appeared as such in the leaflet.
under revision and has been largely retained. For convenience a short resume of present knowledge follows.

4. The wood of Pinus roxburghii is nonporous and is composed mainly of tracheides. It exhibits clearly marked annual rings, conspicuously differentiated into 2 portions, the spring wood containing thin walled cells and large cavities and the summer wood having denser walled cells. A varying number of the outermost annual rings make up the sapwood which is of a somewhat lighter colour than the heart wood which contains but little resin.

5. The outermost layers of the sapwood are richest in resin and according to Mayer the part richest in resin is the root-wood and the poorest is the heart wood. A small scale experiment carried out in the Hoshiarpur Forest Division of the Punjab gave good grounds to believe that resin production is greater in and near the crown of the tree than elsewhere. The part of the hole itself which is the richest in resin is the butt-wood. The side of the tree facing south is richer in resin than the side facing north. A dry climate produces a greater resin flow than a cold one, while a dry light soil yields better than a moist heavy soil. Finally a large spreading crown is a sign of probable good yield and small crowned trees yield poorly.

6. In the sapwood, resin is stored in two systems of elongated passages termed resin ducts. In one system, the ducts are parallel to the axis of the tree, in the other they lie horizontally in radial planes. The vertical ducts are large; often being visible to the naked eye; the horizontal ones are included in fusiform rays and being small cannot be detected without the aid of a microscope. Both types are surrounded by one or two, rows of thin walled resin-cells. Distribution of resin-ducts varies: the vertical ducts number from 15 to 65 per square centimeter and the horizontal from 35 to 65. Both systems are more or less united, since they frequently cross each other.

7. Successful resin tapping depends on keeping the sapwood in a healthy condition. When a cut is made in the sapwood, the growth of tissue near the wound is stimulated and the new wood formed is characterized by
having in it a larger number of resin ducts than are normally found. It is both from the horizontally extended ducts as exposed on a freshly cut longitudinal surface and from the vertically extended ducts as exposed on the cross section that the drops of resin exude. The maximum flow of resin is thus from the top of the "blaze" where both the horizontal and vertical ducts are severed.

3. The process of resin tapping is not merely adrawing out of resin already formed: it is the collection of resin which is constantly being manufactured by the tree, when the sapwood is wounded. The bulk of resin appears to be produced most profusely within a few inches of the wound and not far above it. The wound must, therefore be a perfectly clean cut which fully opens the resin ducts; and wounding must be recurring as otherwise the resin at the cut end of the duct solidifies and prevents further flow.

9. A resin "blaze" correctly freshened shows clean white-wood and a generally uniform distribution of exudation of resin in small clear honey-colored drops. A "blaze" not systematically freshened shows patches of faint dark streaks from which no resin exudes owing to the resin ducts being blocked with solidified resin. The flow of resin is greatest immediately after wounding or re-wounding, the flow gradually decreasing in the process of time until it practically ceases owing to the plugging of the ends of the ducts with solidified resin. The plugged ducts immediately above the wound then become full and the resin tends to diffuse itself over the surrounding wood; this diffused resin does not drain out when the wood is re-wounded.

Experience extending over some 40 years or more goes to show that in order to obtain the most economical results the wood must be re-wounded at approximately 6 day intervals.

10. From the above short resume, certain fundamental deductions can be made in regard to the principles of resin tapping, namely:

1. Resin production will be improved if crops under tapping are maintained in a somewhat open condition.
(ii) The blaze should be placed as low down on the stem of the tree, as possible, while the nearer it is to the south face of the tree, the better will be the yield of resin.

(iii) Deep "blazes" extending beyond the outer layers of the sapwood and even into the heartwood of the trees do not mean a greatly increased yield of resin; on the other hand such deep blazes almost invariably result in the wounds not healing.

(iv) The blazes must always be made with a very sharp instrument so that the wound has a perfectly clean surface.

(v) The "blaze" must be "freshened" by the removal of a very thin shaving of wood from the open part of the blaze at regular intervals of about 5 days.

(vi) Blazes should not ordinarily be continued in length for more than 5 years otherwise the yield of resin will materially decrease. A fresh blaze should therefore be started at the base of the tree after 5 or at most 5 years tapping.

(vii) The whole face of the blaze must always have a clean smooth surface over its whole length to ensure the rapid flow of resin to the collecting cup.

11. Since March, 1915 when the original orders on resin tapping in the Punjab were issued much has been learnt by a process of trial and error. The system of continuous light tapping has been adopted and it has been necessary to introduce more stringent regulations as regards the length, width and depth of the channels.

Section 3—Enumeration.

12. Preliminary operations. Resin tapping schemes are usually embodied in Working Plans and such schemes will not be departed from except with the approval of the authority competent to permit deviations from the prescriptions of such plans. Where, however, such schemes do not exist before any area is to be worked, Range or other officers appointed must in the previous summer examine the whole area carefully and make recommendations to
the Divisional Officers as to which portions of the forest areas should be brought under tapping.

13. Selection of forest area for tapping. In areas already under tapping a similar examination must be made and a report prepared showing the alterations in previous arrangements considered advisable. Areas with very sparsely-studded trees (8 or less to the acre) should be omitted, on the other hand any adjoining areas fit and available for tapping, which had not been originally included in approved schemes should be included.

*Note.- Alterations may be called for owing to lack of further tapping space, serious fire damage, over tapping affecting the health of the tree crops, sale of dry trees, poor resin yield, and so forth.

14. When the boundaries and area of a block or sub-block to be tapped for the first time, have been satisfactorily settled, the area must be enumerated to obtain an estimate of the number of trees and blazes.

15. As trees marked for felling other than in P.B. I are ordinarily to be tapped to death, the marking of such trees should be done as far as possible before the resin enumeration is carried out, so that a proper estimate of the number of blazes in a block or sub-block can be made. Except in areas under regeneration, trees to be felled should be marked 3 to 5 years ahead of the year in which they are intended to be felled, so that the heaviest possible yield of resin may be obtained from such trees before they are felled.

16. No trees will be enumerated for tapping within 8 yards on either side of a footpath or road, where considerable wastage of resin and resin pots is likely to take place through the mischief of wayfarers.

17. Forests included under Unregulated Working Circles and protection forests that are never likely to yield timber should be included in a scheme of tapping if economic conditions so permit. Trees growing in such areas generally stand in open crops and have large branches and are most suitable for tapping.

18. Enumeration work. In the enumeration work, the trees to be tapped to death will be classified from the original marking lists for entry in Abstract Resin Form.
"A" such trees will not be enumerated again, so that only trees to be lightiy tapped will be counted, the results being abstracted from the enumeration note books for the purpose of Abstract Resin Form "A."

39. Re-enumeration. It will not in ordinary circumstances be necessary to enumerate trees every year but care must be taken to prepare a fresh Resin Form "A" when every 5 years as casualities by natural causes or by petty fellings occur. In the event, however, of a serious natural calamity or heavy falling which materially affect the total stocking, a re-enumeration should be made immediately.

40. When a reduced out-put of resin in any year is ordered, this is best effected by abolishing one or more depots and not by a proportionate reduction of work in all depots.

41. Number of blazes-per-tree. For light continuous tapping, the following limits are fixed: girth measurements being taken at breast height over bark, measured on the up-hill side of the tree:

(1) 4 to 6 feet girth, one blaze 4" wide;

(2) above 6 feet girth, two blazes 4" wide.

For heavy tapping the general idea is to put on as many blazes as possible, leaving at breast height at least 2" of bark between every two blazes. For fairly well-formed straight trees, an approximate estimate of the number of blazes may be obtained from the formula X + 1, where "X" is the girth of the tree in feet, ignoring all fractions of a foot.

Thus a 5 feet 7 inch tree will have 6 blazes.

Thus a 8 feet 5 inch tree will have 9 blazes, and so on.

For badly shaped, twisted, trees, or those damaged at the base by fire, falling stones, violets, etc., the number of blazes will be less than this. The minimum girth of a tree which it pays to tap to death is 2 feet.
22. Punch Marking: Every tree shall be serially numbered and the number of blazes indicated: thus 56%3, the upper figure showing the serial number and the lower figure the number of blazes permissible. The unit of enumeration will be the compartment (or sub-compartment where such exists). For marking these numbers, the back is smoothed on the north side of a tree at about 5 feet from the ground and the numbers are punched in lightly with 1⁄4" figure punches.

23. Summary of Enumeration Form "A": Rain form "A" (see Appendix II) will give the result of enumeration of compartments or sub-compartments where such exist and will be a permanent record of work actually done. The form will be abstracted as follows:

<table>
<thead>
<tr>
<th>Division</th>
<th>Range</th>
<th>Block</th>
<th>Year of commencement of tapping or re-plantation</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Lower Blazes</th>
<th>Upper Blazes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Blazes</td>
<td>No. of Blazes</td>
<td>No. of Blazes</td>
</tr>
<tr>
<td></td>
<td>No. of trees</td>
<td>No. of trees</td>
<td>No. of trees</td>
</tr>
<tr>
<td></td>
<td>No. of stumps</td>
<td>No. of stumps</td>
<td>No. of stumps</td>
</tr>
<tr>
<td>3 to 3.5&quot;</td>
<td>3.5&quot; to 4&quot;</td>
<td>4&quot; to 6&quot;</td>
<td>Over 6&quot;</td>
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<tr>
<td>Nil</td>
<td>Nil</td>
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</tbody>
</table>

The abstract will be entered in a register kept in the Range Office a copy being sent for record to the Divisional...
Office where this information shall be entered in Com-
partment History Files (or Forest Journals) where such
are maintained. Non-Government forest areas tapped
should be shown separately in Record Form "A".

24. Time of enumeration. Marking of trees for
tapping to death must be completed during the summer.
Re-enumeration work when done must be taken in hand
immediately after the tapping season is over, viz., by Ist
of November and completed by the Ist of December.
When enumeration is done in a forest, for the first time
this work can be taken in hand earlier and finished by Ist
of December. One Forest Guard with three coffees can
enumerate 400 trees a day.

Section 4.—Tools and Stores.

25. The scale of tools and stores. The following is
the scale of implements required:

<table>
<thead>
<tr>
<th>Article</th>
<th>Specification</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay pot previously with clay lids</td>
<td></td>
<td>Made by village potters.</td>
</tr>
<tr>
<td>Tin, G. J. or long line are made from old kerosene flasks</td>
<td>50 W. G. to 34 W. G.</td>
<td>Annual requirement 2060.</td>
</tr>
<tr>
<td>Iron nails or wooden pegs to support the pole</td>
<td>1½ to 2½ wide nails, about 300 to 350 per piece</td>
<td>1 per hamlet.</td>
</tr>
<tr>
<td>Curved edger, ½&quot; edge</td>
<td>Mild steel standard pattern.</td>
<td>1 per hamlet.</td>
</tr>
<tr>
<td>Grappling straining hooks</td>
<td></td>
<td>1 per hamlet.</td>
</tr>
<tr>
<td>Curved edger, ½&quot; edge</td>
<td>Mild steel standard pattern.</td>
<td>1 per 1,000 knots.</td>
</tr>
<tr>
<td>Plane to pull out leaf.</td>
<td>Iron or mild steel.</td>
<td></td>
</tr>
<tr>
<td>Manoeuvres.</td>
<td>Iron or mild steel.</td>
<td></td>
</tr>
<tr>
<td>Article</td>
<td>Specification</td>
<td>Remarks</td>
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<tr>
<td>---------------------------------------------</td>
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</tr>
<tr>
<td>Flatwooden spades for</td>
<td></td>
<td>Made by tapping</td>
</tr>
<tr>
<td>keeping cutworms from</td>
<td></td>
<td>meadow-creepers</td>
</tr>
<tr>
<td>the pot.</td>
<td></td>
<td>with 2 pin 1 inch, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 inch per foot of meadow-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>growth.</td>
</tr>
<tr>
<td>Clean empty biscornus tines for</td>
<td></td>
<td>2 per foot, 1 inch in</td>
</tr>
<tr>
<td>coloring and storing</td>
<td></td>
<td>pot, 1 inch in pot.</td>
</tr>
<tr>
<td>rods.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubber and wooden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tools.</td>
<td></td>
<td></td>
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<tr>
<td>Slides for weighing</td>
<td></td>
<td></td>
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<tr>
<td>Deposit</td>
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</tbody>
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**NOTES**

1. Clay pots.—It is essential that clay pots should be of given uniform size. If they are smaller than is usual, the nutrient of heavy yield. If they are bigger and not well laminated, they break under the weight of rests or rails. It is, therefore, essential to give the pots a1 laminated specimen. In order to ensure the correct size, the Purps Guards surrounding the pots will be made responsible for this.

2. Tin lips.—Tin lips are much cheaper and can be easily prepared locally from old tins so they can be obtained from other districts where tapping. Tin lips last for about 2 years and G. 1. lips for 10 years.

3. Baskets.—It is advisable to use wooden in preference to clay pots. Iron pots are often removed by the villagers. Wooden pots are cheaper and they can be locally made from hard woods such as Khura (Acacia Catechu), Teak (Tectona) or Semeria. Sometimes the heart of clay is used.

Wooden pots should always be ordered from a carpenter. If this is not done Forest Guards ordinarily have the supply of wooden pots to the require, who makes use of all sorts of wood as the material of a standard size and strength.

4. House.—The meadow are now taken to stores locally obtained. The preliminary treatment is done on a rough stone and later completed on a stone stone (carved in the pocket).
5. This—It is essential that no more drums are ordered than are required during the season as they rust very rapidly and become unsaleable.

6. Drum—Drums had been introduced to reduce the cost of containers. Their life has been estimated at 6 years. The number of 50 gallon drums required for any steam depot depends on—

(a) the average daily output of rails during May, July and August; and

(b) the number of days the finished drums spend in transit to their destination and back.

Example—Supposing the daily average collection of rails on a depot during the months of May, July and August, is 3700 rails and the number of days spent on the return trip to rail by rail depot (where the 50 gallon drums are supplied) is 6 days. The number of drums required will be double the number needed to contain a daily output. Half the number will be travelling between finished depot and rail depot, the other half will be available for filling.

Similarly, the number of 40 gallon drums required for the rail yard or yard depot can be worked out in the basis of the daily average arrival of rails from exam depot and the number of days required for a return trip to the factory. The number of drums can be further reduced if transport can be speeded up, i.e., if the transit time is cut down to 3 days or less.

As the out-put during June is higher than the average daily out-put during May, July, and August, a certain number of drums (10 per cent of normal requirements) will be kept as a reserve in drum depots against an emergency. These will be transferred to the depot as soon as the average daily out-put falls to normal.

As there is no Government-owned factory at present, the use of drums is suspended.

25. The following scale of stores is laid down for use in rail depots. The indent and consumption of these stores will be based on this scale:

- Solder 8 chf, for 100 tins.
- No-bad silver 1 chf, for 100 tins.
- White paint 6 chf, for 100 tins.
- Black paint 3 chf, for 100 tins.
- Charcoal 10 ears per 100 tins.
- Charcoal for repairs of tools: 1 30 per tool.
- New tins for soldering 2 per 100 tins.
- Old tins for soldering 4 per 100 tins.
27. Time and method of indent. The indent for tools should be made in good time, stating clearly the definite quantities required and the maximum permissible gross weight per package.

28. Writing of unserviceable tools. Much confusion results in indenting for stores if the unserviceable tools in forest depots are not examined annually, and written off. It will also save correspondence between the Divisional Officer and Range Officers if unserviceable tools can be examined by the Divisional Forest Officer on tour so that by the end of the tapping season each depot is in a position to prepare a correct indent for the following year's supply.

29. Disposal of unserviceable stock. It is essential that effective methods be employed in destroying unserviceable stores and if this is not done they are liable to be presented over and over again for writing off. Certain articles can be broken or burnt, others can be thrown into a river. Old tins cannot be destroyed in either of these ways they can either be converted into lips if these are required or a hole punched in the bottom centre of a tin will permanently prevent its use. Other methods may be devised by the local Divisional Officers. The method employed must be effective. Sell if there is a demand for old scrap iron, otherwise the only effective method of disposing of such tools is to throw them into a river.

SECTION 5.—Fastening of lips and posts.

30. Cutting new channels. Scrape the rough bark over a width of 6" and to a height of 2" over that part of the tree which will be tapped during the year leaving only 3/4" thickness of bark. This operation probably increases the output of resin as the rays of the sun have a better play on the resin ducts. Moreover the application of the slates becomes easier during refreshing. Then mark the lower end of the channel by a chisel or knife so that in the process of cutting a new channel, unnecessary injury to the cambium below the lip site is avoided. Cut the channel 4"×4" and 3/4" deep in the middle.

31. Fising of lips. At the lower end of the channel drive a chisel to a depth of 3/4". Allowing 3/4" for the depth of the channel, this leaves 3/4" of depth for the lip. The shape of the chisel is such that it gives the cut a slope as the chisel is driven in with the hammer so that when
the lip is fixed it assumes a sufficient slope to allow the resin to flow into the pot. But to ensure sufficient slope for the lip it should be seen that the chisel cut is at an angle not less than 45° otherwise the resin will evaporate as it drips slowly and will collect on the lip.

Before the chisel is taken out, a lip is placed on it and with a light stroke of the hammer bent to give it a curve similar to that of the chisel and of the cut. The chisel is then pulled out and the lip is immediately driven home and the outer corners of the lip turned up. If the lip is not driven immediately after the chisel is withdrawn the cut meets again and it is not possible to drive the lip home without re-opening the cut.

It is essential that the lip should be driven home to the full depth of the cut, if this is not done a gap will be left between the lip and the tree and resin will run to waste. For the same reason chisels should not be rounded at the corners, as a shallow cut at the corner will permit the lip to be driven, hence. Before commencing the second or subsequent year's work the lip is pulled out, collected, burnt (to remove old dry resin) straightened and then the lip and pot are moved up the length of the old channel leaving 4' from the top. This ensures the minimum distance for resin flow and prevents evaporation and solidification of resin on its way to the pot.

33. Firing of nails. The nails are driven into the bark immediately above the cambium on one side of the channel so that pot hangs in position to receive the resin dripping from the lip.

34. Size of pots. All pots will be of uniform size, 6" deep, 4" in external diameter at the top and 3½" at the bottom.

35. Preparation of pots. Pots should be prepared as near to the forest as possible and delivery should be taken in the depot or in a central place in the forest. Counting should be done by a reliable person and he must furnish a certificate on the bill that the pote were counted in his presence. The rate for the preparation of pots includes cost of transport to the forest or resin depot.

36. Season of making pots. First November to 15th December is considered the best season for making pots. They should be ready before the winter rains. If this is not done potters will not be able to make them until the middle of March and tapping will be delayed.
A potter can make 500 pots a day and the same number can be baked at a time. It takes a week to complete the whole operation.

36. Collection of pots. In old work, the pots are safer on the trees and collection is an unnecessary expense except where breakages are heavy or in localities of heavy snow. In the latter case, the collection and storage in a dry place is necessary. By leaving pots hanging on the trees much winter resin is collected which will otherwise be wasted and the surroundings will be kept less inflammable. Where pots are not collected along with the lips, a lower rate for raising the lips and pots should be paid.

37. Hanging of pots. In new work the hanging of the pots is done after the lips are placed in position so the gazers cannot carry about baskets full of pots—along with a number of tools and lips, consequently this is paid for separately.

In old work pots are already on the trees and the gazers merely put them up after refixing the nails. In this case broken pots must be replaced at the same time. The hanging of pots in old work forms part of the routine, and is not separately paid for.

38. Replacement of broken pots. In setting up crops it is a common practice to hold over the replacement of broken pots to the beginning of the tapping season with the result that very often this is neglected for a long time and considerable wastage of resin takes place. This work must be done immediately after raising the lips and labour should not be paid until this has been certified.

39. Duration and season of setting up the crop. This work can be done in one month in any depot provided one mazdoor is employed per section. If other departmental works do not require the Forest Guard’s attention elsewhere this work can be taken in hand on 15th of February, and completed by 15th of March. Otherwise it should be started on 1st of December and completed partly before the winter rains and partly after.

40. Rate of work. A man can pull out 400 lips a day. He can complete 60 channels per day, including fastening of the lips, refreshing on opening of new channels, fixing of nails and hanging of pots.

Section 6.—Tapping work

41. Tapping Unit. A tapping unit consists of a section worked by one mazdoor. Ordinarily it contains
1,000 channels. The number of trees per section varies from 600 to 700. Each manapor therefore refreshes 1,000/6 which equals 167 channels daily and collects resin from them, so that he can go over the section once in 6 days and thus refresh each channel 5 times a month.

In order to accomplish this a manapor sub-divides a section into 6 parts by artificial or natural boundaries so that he can go over each sub-section in a day. The average number of sections in a resin depot is 10 to 15, but a large number of sections can be attached to a depot if the configuration of the ground justifies easy control.

The seasonal cutturn for a full working season (16th March to 16th October) should be about 70 manaps per section. This cutturn however, varies a good deal. It has been more than 100 manaps per section.

42. Tapping Season. The initial expenditure on setting up a crop remains the same whether the tapping work is carried on for a longer or a shorter period. In other words the cost of resin per manap for the season will be less if tapping is continued for the longest period possible and this should always be done.

Ordinarily tapping should begin on 16th of March and should continue for seven months ending on 16th of October and in warmer localities to 16th of November. There is a tendency both among the subordinate staff and manapons to start late and wind up the operations earlier. This must be strictly forbidden and the tapping season should not be reduced without the express sanction of the Divisional Forest Officer. During September and October harvesting and grass cutting is likely to interfere with the supply of labour in some localities (not everywhere) and local variations in the tapping season may be necessary.

In cooler localities the resin flow begins late and fails off earlier and in such localities the working season may be shortened by a few weeks. This may be done under the express sanction of the Divisional Forest Officer.

43. Spacing between the channels. The points of the stem most favourable for resin production are those directly facing the sun. Starting with a girth of 4 feet and spacing each successive channel with an interval of 44" of bark in between it should be possible to tap the tree for 25 years omitting all considerations of occlusion. The channels must be cut vertically upwards and where
necessary a vertical line will be marked with a centibe before hand. The taper in the tree will not permit a uniform spacing of 4½ inches above breast height. In order not to reduce unduly this allowance of bark the standard width of 4½ is to be reduced to 3½ in the 5th year of tapping. It sometimes happens that the annual quota is completed before 15th of October and tapping operations are brought to an end forthwith. This should not be allowed as output per thousand blazes for the season will be low.

44. Refreshening of channels. The pot should be removed before refreshening as otherwise it is likely to be filled with bark, chips and shavings.

A thin shaving is removed from the top curved part of the channel in order to open up closed resin ducts. In doing so the channel is lengthened by 1¾ to 2‰. The total length of the channel to be refreshed will be 4‰ for the purpose of opening closed ducts and another 2‰ lower down to smoothen up the surface.

45. Thickness of shaving. The thickness of the shaving varies from 1/10‰ to 1/32‰. The shaving must not ordinarily be too thin or it will not open clogged resin ducts. During May and June when the greatest heat prevails the shaving can be as thin as possible. The cut must be clean and not torn or jagged particularly in the neighborhood of the cambium and must taper to a feather edge where the cut and the cambium meet. If this is neglected healing will be retarded. However, it is not always possible to avoid this in trees with twisted fibres.

46. Depth of channels. All the sapwood in chin contains resin. The size of the longitudinal resin ducts is far larger than that of transverse ducts. Consequently deeper channels in sapwood give definitely more resin than shallow ones. But channels deeper than 1‰ do lasting damage and considerably delay the process of healing.

It is a common fault to cut deep channels to obtain a greater yield. This is due to the following reasons:

1. Untrained labour. It is the duty of the staff to see that the labour is properly instructed.

2. An excessive curve in the cutting edge of the adze. This should always be checked.

Worn out corners of the cutting edge also tend to deepen the channels. This can be prevented in repair ing; adze with badly worn corners should be written off.
(3) A channel gauge with graduated scale as shown in diagram No. 34 can be profitably introduced for the use of all concerned. This can be fixed to the handle of the scraper for the use of coolies.

47. The interval and number of refreshenings. Refreshenings must be done at regular intervals at the rate of 5 refreshenings per channel per month and the total number of refreshenings carried out during the year on each channel will vary according to the length of the season and will be 30 during 6 months tapping and 38 during 7 months. It has been found in practice that some trees give an abundant yield of resin in the month of June without being refreshed. Others are poor yielders and are neglected by the mazdoors. A channel which is not refreshed at short intervals ceases to give any yield of resin.

The colour of the channels over the section will show if the mazdoor has been working regularly or has neglected his duty.

It is also easy to determine from the length of the channels at any time of the year whether the refreshing has been done regularly or not.

With five refreshenings a month the channel will be lengthened by $\frac{1}{12}$ a month, so that if tapping is continued from 16th March, to 15th October the length of the channel at the end of 7 months will be 15" plus 4" its original length at the beginning of the season, or in all 19". In subsequent years the channel will be lengthened by 15" every season.

48. Maximum height to which a tree should be tapped. In the Landes tapping is done to a height of 12 feet. The determination of the height to which tapping should be done depends on the importance of resin versus timber production. The best course seems to be, carry out tapping so that its adverse effect on timber production is reduced to a minimum.

The yield of a new channel is low for the first year and it continues to increase during the 2nd and 3rd years and gives a maximum output during the 4th year. It begins to fall in the 5th year by which time the height of the channel has reached to about 7 feet.
It is possible to tap this height without the use of a ladder, even when the channel is on the down-hill side of a tree by piling up a few stones to stand on.

A good deal of timber in the butt logs is wasted as the height to which trees are tapped varies. It is, therefore, necessary to limit tapping so that the timber in the tapped butt log can be utilized. For this purpose 7' is a very desirable length as it is possible to convert the butt log into planks (7' x 3' x 1') or scantlings which can be converted into boards (sides of bed 7' x 2' x 2 1/2'}. It is consequently uneconomical to tap a channel for more or for less than 5 years.

A very objectionable practice is to start a new channel without tapping the old channel to its maximum height. Sometimes a channel is tapped beyond 7' with the result that a further length of the butt log is wasted. In order to prevent individual mazdoors tapping to various heights it is necessary to cut a belt round the hole 7' from the ground level so that each channel is carried to that height. In the case of trees having partially-worked channels it should be seen that all channels are worked to their maximum height one after the other before any new channels are cut.

46. Collection of resin from pots. Ordinarily a pot should be emptied into a clean collecting tin once every 6 days, in other words, this is done as refreshing proceeds.

During the month of heavy flow in June the pots are filled in about 4 days and the mazdoors go round collecting resin every 4 days. In such cases as refreshing work cannot keep pace with the collection they do not refresh the heavy yielders and only remove a very thin stratum from other trees. Sometimes they place an extra pot on the ground to receive the overflow. This leads to wastage and dirty resin.

The best course to follow during the month of June is to continue the refreshing and collection at regular intervals, but the mazdoors should go round once in 4 days collecting from the heavy yielders only. This is not difficult as with practice the cookies soon recognizes such trees.
50. Adulteration of resin. Sometimes resin is adulterated with mud grit and stone. This is done by mad-dogs and depot guards to increase the weight or to make up deficiencies. If the cleaning of resin and filling of tins in depots is conducted under proper supervision, this can be avoided. The depot guard is responsible. The inspecting staff should examine a large percentage of tins before they are soldered. The present system of marking tins is a safeguard against adulteration and should be continued.

51. Tapping to death. All trees marked for felling except in P. B. I. should be tapped to death for 3 to 5 years before felling. It is not possible to fix limits on trees below 1"-6" in girth and 2′ is a suitable minimum girth for tapping to death.

52. Yield. The graph attached shows the yield during the season. As yield varies from place to place according to locality local tables may be prepared to show the yield per 1,000 blazes so that the progress of the yield month by month can be checked.

53. Resting period. No resting period is necessary under light continuous tapping except where sufficient space is not available to permit a spacing of 4½′ at breast height between channels.

Sometimes on rocky and poor soil trees begin to die. In such cases the question of stopping tapping should be considered.

54. Period of healing.—Very little is known about the rate of occlusion and further observations are absolutely necessary on this vital question. Mr. Champion records the following in the United Province Forest Bulletin No. 63:

"The rate of occlusion of resin channels in Pinus Longifolia depends primarily on the general vigour of the trees as indicated by its degree of maturity, the development of its crown and its height growth and secondarily on an adequate supply of water and food material reaching the edges of the wound, conditions being optimum on the north side of a tree on northern aspects at about 8,000′ altitude at the foot of the tree and in the case of a left handed twist tree on the left hand side."
It has however, been proved in an experiment conducted in Rawalpindi East Forest Division, that tapped trees put on less increment than untapped trees. The result of observations conducted has been shown in the attached graph.

Deep and burnt channels take much longer time to heal.

Section 7.—Storage and Transport

55. Resin Depots.—Resin depots will be located as far as possible within of near the tapping area. They will be easily accessible to transport animals.

Depots will be kept neat and clean, and no grass or other inflammable material may be stored nearby. A precaution against fire a clean belt will be kept at hand. Empties will not be stored in the open for any length of time, as they become rusty, leak and rapidly deteriorate.

Collection and storage.—After collection the coolies bring their resin to the depot where it is passed through a sieve and then filled into empty tins which are then weighed, closed and numbered. Each depot is assigned distinguishing letters and each tin is numbered serially so that it is easy to check the receipts of any particular depot. If drums and tins are too full, leakage occurs during transport in the hot sun owing to expansion. It is strictly forbidden to heat resin for transfer into tins or drums, and tins should not be left uncovered for any length of time as the turpentine evaporates and the quality of the resin deteriorates.

56. Road transport.—It is a common practice with pack transport to take charge of a larger number of tins and drums, store them in their homes and then gradually transport them to railhead or cart depot at their leisure. This practice is open to objection as tins often remain in transit for months.

This practice is resorted to by the transport to ensure continual work for their animals and by the resin guards to show quick despatch. Depot Guards should therefore have instructions to hand over no more resin than can be carried by the animals available, to give over no more until the previous challan has been returned duly receipted.
37. Penalty for delay in transport.—The difficulty mentioned above can be overcome by imposing graded scale of penalties for delay in transport in all carriage contracts.

38. Transport.—Resin collected in the forest depot should not be stored for long. It should be transported forthwith to rail-head or cart depot or sale depot. Where drums are used speed in turn-over is essential to economical working.

Section 8.—Fire Protection

39. Tapped areas are liable to fire, and if the resin channels are badly burnt the death of the trees frequently follows.

40. Departmental burning of tapped areas.—Ordinarily most of the chirm areas are prescribed under working plans for departmental winter burning. During this operation all highly inflammable material found in the area must be disposed of.

41. Disposal of needles, chips and earth saturated with resin.—A certain quantity of resin flows down the old channels and saturates the earth, needles, and chips lying at the base of a tapped tree. During the winter departmental burning operations, this must be disposed of in one of the following ways:

(a) The needles and chips are swept clear to a distance of 3' to 6' from the tapped trees and the saturated earth is dug up and burnt or otherwise destroyed.

(b) Refuse is burnt under supervision in situ to a distance of 3' to 6' round every tapped tree.

After all tapped trees have been thus dealt with the area is burnt departmentally in accordance with standing orders. It is to be remembered that if the pine needles are partially wet the fire only travels on the top of the leaf layers leaving the lower layer unburnt or only charred. Burning should therefore be done at a time when complete combustion can be insured.
82. Summer Precautions.—During the tapping season the resin mazdoors must clear all needles, chips and inflammable material to a distance of 3' all round tapped trees on the level and to 3' above and 6' below on the sloping ground.

At the close of tapping operations in September and October it is necessary to see that the trees are so left clean all round. If a mazdoor is slack and does not carry out this work payments should be withheld until his areas are clean.

At the close of the working season the Resin Guard should certify on the bills for the collection of resin that the trees had been left clean before the mazdoors are finally paid off.

Section 9.—Duties of Staff

83. Duties of Resin Guards.—(1) They will see that the size of pots brought is correct. For this purpose a specimen must be made over to the potter.

(2) At the time of setting up the crop they are responsible that the channels are properly cut to depth and shape, that the lip is properly fixed so that the resin trickles into the pot, that the pots do not contain dirt and chips, that the ground surrounding the tree is clean, and that it is so kept during the tapping season. They will go on the work at frequent intervals to see that all mazdoors are not tapping too deep and to instruct them in their duties. They are to replace all incompetent mazdoors who refuse or are incapable of learning their work.

(3) That the attendance of workmen is regular and that refreshing and collection is done systematically, and at the regular prescribed intervals.

(4) That all broken and unserviceable pots are replaced, and that all pots are properly covered.
(5) That all persons employed in the forests are acquainted with their orders on the outbreak of fire.

(6) That all tapping edges are kept sharp and in good order.

(7) That all workmen are fully instructed in all their duties and made competent in the execution of their work.

4. Duties of Range Officers and Assistants.—(1) To see that the tapping rules are strictly observed by all concerned.

(2) That the Forest Guards and mantloors carry out all duties assigned to them.

(3) During the months of April, May, and June to examine depot stores and sort out personally all unserviceable tools and to have them examined by the Divisional Forest Officer.

(4) That all the registers are properly kept and entered up daily, and that the stock register tallies with the stock in depot.

(5) That a reasonable reserve of poles is maintained for replacing broken ones, and that excessive breakages are brought to the notice of controlling officers.

(6) That the transport of resin to cart depots or railway or sale depot is keeping pace with the output.

(7) Every range officer will inspect every tapping area and resin depot at least once every two months and will record his remarks in the inspection register.

68. Duties of Divisional Forest Officer and Geodetical Assistant.—The Divisional Forest Officer will inspect each depot and the tapping areas attached thereto at least once during the season, and will see that all orders regarding resin tapping are being properly carried out; he will inspect and check the depot books, see that the yield per 1,000 channels is up to the standard, that transport is not delayed, and that all the resin tools are in good order. He will inspect unserviceable stores and have them destroyed in his presence. He will record the results of his inspection in the inspection book.
SECTION 10.—Resin Records, Registers and Forms

66. In order to organize resin work properly and to enable a permanent record of operations and their cost to be maintained the following forms will be maintained:—

Resin Form A is shown in Appendix II and its abstract already referred to in paragraph 23.

Resin Form B showing the monthly account of resin operations range by range, each block or group of forests concerning one resin depot being entered separately for purposes of statistical record and check of costs. Combined abstract forms A and B is suggested for adoption.

Resin Form C which is a modified Form 7.

Resin Form D. On 15th March each year Divisional Forest Officers will send a report of resin operations for the past season to their territorial Conservation with explanatory notes explaining fluctuation in figures. The object of this form is to check costs and any tendency to uneconomical work.

All these forms are shown in Appendix III.

67. Depot Forms.—The following forms will be maintained in Resin depots:

1. Register of daily collection (in current use).
2. Form 6 showing daily receipts.
3. Form 6 showing disposals.
4. Inspection Register (Appendix II).
5. Stock Register (in current use).

68. Fortnightly Progress report (Appendix II) will be submitted by Range Officers to Divisional Forest Officers. They will show out-put for each depot separately comparing the same with the out-put per 1,000 blazes. If the out-put in any depot is low as compared with the other resin depots or as compared with the out-put of the previous year for the same fortnight it means that the
work of refreshing and collection is not being systematically carried out. Factors such as newly tapped areas, unusually wet and cold season responsible for such differences may be stated in the remarks column.

APPENDIX I

The commercial exploitation of the resin of the Indian pine serves a wide range of subsidiary industries. It provides, resin for shellac making, soap manufactories, paper concerns, oil clubs, linoleum, sealing wax, printing inks, electric insulation, gramophone records, and wheel grease. And it also provides turpentine, which is the chief thinner and solvent employed in the paint and varnish trades a mordant in print goods manufacture, the basis of synthetic camphor, and an ingredient of boot polishes, embroidery and limings. This field is wide enough in peace time, but was considerably expanded in war time by the resin used in "setting" sharpnel bullets in shells.

Of the world's trade in resin and turpentine or "naval stores," the United States of America command about 30 per cent. of the out-put, France coming second with some 15 per cent. and the rest of the world taking the remaining 5 per cent.

It is now well over forty years since forest officers in the North-West of India began to realize the potentialities of the wide pine belt along the foothills and lower slopes of the Himalayas. Many of them being French trained it was not surprising that the splendidly organized tapping of the maritime pine of the Landes should serve them as a model, and so from the very start the conservative cup and dip method in use in France was adopted thus ensuring the best possible yield of resin with the minimum risk of injury to the tree. And so from small beginnings in the United Provinces, and later in the Punjab the industry has grown and for the year ending on 31st March, 1949, the resin collection in the United Province and the Punjab amounted to 125,333 mounds net (4,615 tons) the operations covering 97,538 acres of forest with 2,766,142 bales or channels in work, giving employment to at least 4,000 operatives.

Since 1912 both in the United Provinces and the Punjab extensive and successful organization has brought
the harvesting of the resin to a high state of efficiency. Mr. E. A. Smythie's interesting pamphlet on the "Resin Industry in Kinaum" Forest Bulletin No. 25, 1914, is available for those who wish to study the question further.

The work of setting up a crop of pots (or cups) and tips preparatory to tapping pine trees for resin is simple, when properly organized, and the resin collection in the forests offers exceptional opportunities to the surrounding villages to utilize the old and the young for earning excellent wages.

The bark of the tree to be tapped is first of all lightly smoothed; then, as close to the base of the tree as possible, the bark is entirely removed so as to expose the sap-wood on a strip some 6 inches high and 4 inches wide. A galvanized iron lip 6 inches wide by 2 inches deep is driven in at the lower end of this strip or gash and an earthen pot made by local village potters, is hung below the lip, being kept in position by a nail or a hard wood peg. This preliminary work is done in the winter months.

The tapped forests are grouped into depots, sub-blocks and blocks for purposes of control, the unit of work being a section of 1,000 blazes (equivalent to an average of 700 trees spread over 25 to 30 acres of forest) in charge of a tapping Mondor, and the unit of control being a depot taking the produce of about 25,000 blazes or channels.

The tapping Mondors at the beginning of the tapping season, sometime in March, cuts away the sap-wood on the already prepared strip to a depth of about 1" thus serving the resin cuts and channels in the wood and causing the clarified resin to flow down the cut surface over the guiding galvanized lip into the cup below. These severed channels clog after a while, and the whole art of the tapping lies in refreshing the blaze at fixed intervals, gradually extending it upwards till at the end of the seven or eight months embraced in the tapping season, the blaze should be about 24 inches long, and the Mondor in charge of the section of 1,000 blazes should have delivered 45 to 55 mounds net (say 2 tons) of resin in his depot.
Work goes on in this way for five years, the lip and cup being raised annually with the increase in height of the blaze, so as to reduce the distance the resin has to flow before reaching the cup, as the resin oxidizes (and deteriorates commercially) very rapidly in contact with air. In the fifth year of tapping the mandoor has to be furnished with a light ladder to reach the work. After five years the blaze is left alone and a fresh one is started, and so the tree continues yielding resin uninterruptedly for some 60 years out of its normal life of a century and a quarter. Trees under 3 feet girth are not tapped and above this girth the number of blazes varies with the size of the tree. The modern system of continuous light tapping is described at pages 49—51 of Mr. E. A. Smythies' new working plan for the Nainital Forest Division, United Provinces (1918). Those trees destined to be felled within five years of the time of starting tapping are specially heavily worked for their resin, a move, to quote the French expression, with this necessarily brief account the forest operations connected with the harvesting of the resin have to be left in the hands of the factory processes and the markets taken up in review.

It was in the factories and in the selection and devising of manufacturing methods best suited for the distillation of the Indian pine resin that the Forest Department found its hardest task in which the Forest Research Institute at Dehra Dun and the Imperial Institute, London, gave much helpful advice and assistance. American, thanks to the happy chemical constitution of its principal pine resin, produces a turpentine which stands in a class by itself though manufactured in the most primitive direct fire-heat apparatus. French manufacturers found, but not till they had learnt by bitter and costly experience of adverse trade criticism and adverse markets, an apparatus good enough for the maritime pine resin of the Landses, and so, since 1900 or thereabouts, technical French engineers at Bordeaux, energetically assisted by the chemical section of the Bordeaux University, have devoted much attention to the subject of resin distillation. The result has been: a score or more of patents, in all of which fire heat is eliminated and complete control of temperature is maintained by systems of steam heating, steam injection. France has thus been enabled to the best with its pine resin and produces resin with a good
reputation in the trade and thoroughly sound merchantable turpentine.

The lesson learnt in France gradually penetrated to India. The primitive still first used in the United Provinces was re-modelled and modified and now U. P. possesses batteries of stills of the best French type, steam operated and modified to suit Indian conditions, which are giving entire satisfaction by the excellence of their products and the economy of their working. The Indian resin has been recently pronounced in some respects superior to French resin by the well known paint and varnish firm of Messrs. Wilkinson, Heywood and Clark, Limited, London, and large scale commercial tests are now in progress to determine definitely the commercial value of Indian resin in relation to American, French and Spanish resins. Such tests will materially assist the Forest Department in capturing the whole of the Indian trade and that of Java, China, and possibly even of New Zealand and Australia, with which markets' sound export business is already being built up. The Indian turpentine, too, has been standardized, and certificate No. 1760-C., dated the 7th July, 1916, of the Railway Board Test House, Alipore, testifies that the sample submitted (Jaflo Factory, Quality I) gave "a very satisfactory paint film" and "should prove suitable for paint manufacture."

A short account of the actual distillation of pine-resin as carried out at the modern Government turpentine factory (managed by the Punjab Forest Department now in Pakistan), Jaflo, Lahore District, may be of interest. The resin received from the forest is taken out of the air-tight receptacles, loaded into tin-wagons and conveyed along an elevated tramway to large melting and straining vats. There the resin is melted and mixed, steam heat only being used, the melting being assisted by the addition of turpentine from a previous distillation. The specific gravity of the resin is thereby reduced so that when the melting and mixing is finished, a period of rest enables the water and dirt, etc., to sink by gravity to the bottom of the vat, the clean light resin floating on the top. Evaporation is prevented by the lids of the vats being fitted into water joints. The next stage consists in drawing off the clean resin to a storage tank, whence a measured quantity is taken over as required into a steam elevator and thence into the still.
In the still, which is steam jacketed and kept hot by steam under pressure, giving one a range of temperatures, the turpentine in the resin is driven off by injecting steam. The water and turpentine vapours first pass into a trap still to prevent any resin or resin accidentally driven over from going further, and then through a condenser in which they liquified and whence they flow into a mechanical separator, the turpentine passing over trays of lime to remove acidity and then being pumped to bulk storage while the water runs to waste.

To ensure standard qualities the turpentine is redistilled in a subsidiary still, again passed through lime to remove any traces of resinous acids, and dehydrated by being given a period of rest in bulk storage tanks. Experiments are also in progress to dispense with redistillation. The fractionating the distillate in the primary distillation. The turpentine is put for sale in five-gallon drums bearing distinctive stand marks, bung-hole clips and labels, to prevent tampering by retail traders.

The hot resin in the still is drawn off by means of a stub-stake valve into a wagon and transferred to the resin shed, where it is filtered through a layer of cotton wood and then run into cans, bags, or tins while still moderately hot and fluid. The resin is graded according to American Standard into pale, medium, and dark shades. Gross-weight, etc., are carefully stencilled on the packages before despatch. The resin has proved uniform in quality, very clear and free from dregs, a most important matter in paper and shellac manufacture.

A maund of good resin yields on an average 7/10 of a maund of resin and 2 gallons of turpentine of which up to 1.6 gallon is quality I.

The possibilities of development of the Indian pine resin industry are considerable. The average annual consumption of "naval stores", in India based on statistics for the financial years 1907-08 to 1916-19 was, for resin 99,119 maunds, and for turpentine (including turpentine substitutes) 245,729 gallons. In 1907-08 the Indian factories produced only 6,608 maunds of resin and 36,006 gallons of turpentine and in the intervening 12 years have succeeded
In increasing their output tenfold, import of American origin decreasing proportionately. At present the resin industry is practically in the position of having to retard or accelerate its expansion with direct reference to the speed with which the remainder of the Indian market can be secured and outside markets, such as Java, China, etc., developed. It is here that closer co-operation with the trade interests of India is necessary, and more active measures have to be adopted to advertise Indian resin and turpentine.

So far only the resin of chitra pine, Pinus roxburghii, has been dealt with commercially. This pine covers some 1,560 square miles in Government forests and another 1,830 square miles in Indian States, while the blue pine, the Khasia pine and Pinus Merkusii, the resin of all of which has been well reported on, extend over some two hundred, eighteen hundred and twelve hundred square miles respectively, all under the control of the Forest Department. It would not be safe to assume that even half of the Government-owned area will ultimately prove workable, but these figures are sufficient to show that the revenue now derived from this industry is only a fraction of the return which may one day be realized. Recent expert estimates place Indian production at 800,000 mounds of resin and 800,000 gallons of turpentine a year, ten years hence and ultimately, at double those figures, that is 43,000 cwts. of resin and 120,000 cwts. of turpentine a year.

The industry is, therefore, one to which in recent years the Forest Department has rightly devoted a good deal of attention, and though expansion must be gradual, yet the prospects are there, and it only requires effort along sound commercial lines to reap a good harvest. Any forest industry which yields such satisfactory financial results and yet leaves the main source of forest wealth, namely, the timber, a realisable asset, is deserving of the most careful study.

SUPPLEMENT TO APPENDIX I.

It is necessary to add a supplement to Appendix I in view of the developments that have since taken place.
Distillation.—The process of resin distillation by steam injection has been replaced by the more efficient process of distillation by a plant perfected for vacuum distillation in France. The advantages of this process being

(a) saving in distillation time.
(b) an improvement in the grades of resin obtained.

The process starts with the melting of the resin, by enclosed steam pipes in a reinforced concrete tank, turpentine being added to reduce the density. The liquid resin is then passed through a net of sieves and then pumped into a concrete settling tank. The sieves having removed the greater impurities, the water-dirty resin is drawn off from below the settling tank and treated separately. The clean resin is next drawn through a vacuum still by a vacuum pump. During the progress of the resin through the copper tubes inside the still, the turpentine vapours, and is passed through a series of fractionating columns to obtain the different grades of oil. The molten resin is drawn off and filtered through cotton lint before filling into wooden casks containing about 64 pounds of resin.

Sun bleaching of Resin.—The bulk of the resin obtained directly from the vacuum still is so pale as to be classified as Grade A, i.e., one grade higher than W. W., which was the palest grade obtained hitherto. This pale resin is further subjected to a process of sun bleaching in open trays of galvanised iron sheet, and in a period of 2-3 months is converted into extra pale resin of grades 6-A and 10-A.

Yield.—The yield of resin by the vacuum process is slightly more and that of turpentine slightly less than that obtained by the old steam injection process; the actual figures being 78 per cent., against 70 per cent., obtained previously and 1.3 gallons of turpentine against 2 gallons.
## Appendix II

### 4th Form A

<table>
<thead>
<tr>
<th>Division</th>
<th>Forbes</th>
<th>Block</th>
<th>Compartments</th>
<th>Sub-compartment</th>
<th>Test of measurement of tipping</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>Light</th>
<th>Heavy</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>No. of trees</td>
<td>No. of lines</td>
<td>No. of trees</td>
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<td>33 6' 5'/11(2)</td>
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<td>4^(1/2)</td>
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<td>Over 6'</td>
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<td>Total</td>
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</table>
## APPENDIX II—CONTD

**RECORD FORM B**

Monthly account of *Crude latex (mili.)* for **19**

<table>
<thead>
<tr>
<th>Name of Range</th>
<th>Locality and posting</th>
<th>No. of acres of range</th>
<th>Acres tagged</th>
<th>Month</th>
<th>Yield in mili. per month (metric)</th>
<th>Cost</th>
<th>Actual weight at end of month (gms.)</th>
<th>Percentage</th>
<th>Additional notes to be filled at the end of the year</th>
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</table>
APPENDIX II—CONTD.

Resist Forest C.

Forest Department, Punjab

Division

Receipts and losses of produce in depots during the month of 19

<table>
<thead>
<tr>
<th>Name of Depot</th>
<th>Description of Produce</th>
<th>On hand 19, net</th>
<th>Received during the month, net</th>
<th>Disposed of during the month</th>
<th>Net disposed of</th>
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</thead>
<tbody>
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Note—This form can also be used for receipt and store of tree materials on which a very careful check has to be kept.

Station: ________________________  Officer-in-charge: ________________________
Dated: ________________________  Dept: ________________________
### Resin Form D.

1. Year.
2. Division.
3. Acres tapped.
4. No. of trees tapped.
5. Total blazes.
6. Average per tree.
7. Total resin obtained.
8. Average per tree.
9. Average per 1,000 blazes.
10. Cost of labour's wages per maund net resin collected.
11. Cost of bonus to labour per maund net resin collected.
12. Cost of carriage of resin per maund net, forest to rail head.
13. Cost of carriage resin per maund by rail to Destination.
15. Total charges for setting up new crops in the year inclusive of pots.
16. Total charges for raising lips inclusive of pots.
17. Total cost of packing crude resin, e.g., carriage and cost of tying, soldering, killer, etc.
18. Total cost of tools, stores and plant supplied not included in columns 15–17.
19. Total cost of permanent and temporary establishment or resin works and charges.
20. (a) Cost of establishment per 1,000 blazes.
21. Rent and other E charges not entered in column 19.
22. Average per mound net of resin collected of each given in column 19-20.

22. General remarks on climate and nature of season, labour supply, etc and information which may be of use for striking a fair average—cite column 21.

23. Grand total average cost of delivery of a mound net of resin at sale depot.

Note.—As for column 21.
## Forest Survey Progress Report of Beef Collection

**Main of Census Report**

<table>
<thead>
<tr>
<th>Forest</th>
<th>No. of Census</th>
<th>Relief</th>
<th>Number of Tract</th>
<th>Average</th>
<th>Last Balance</th>
<th>During the Period</th>
<th>Total of the Date</th>
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<th>Current Year</th>
<th>Previous Year</th>
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<th>Previous Year</th>
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<td>9</td>
<td>10</td>
<td>11</td>
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**Note:**
- Estimated yield shall be worked out from the number of steps in the forest and average output per thousand steps for the district, area, or locality as may be suited by Divisional Forest Officer.
- Cattle of deer need not be filled where collection is done on contract at fixed rates.
### APPENDIX II—Concluded

**COMBINED ABSTRACT Form A. and Form B.**

*Years of commencement of tapping (when tapping first began)*

| Date | Name of Forest | Light Tapping | Heavy Tapping | Total | Annual township
<table>
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<th>Year</th>
<th>Name of Forest</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>Total</th>
<th>Total cost</th>
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</table>

*Depot*

*Division*
मारुक बनाना।

वाल, वस्त्र बनाना, ऊपर निकालना।

वाली लेखन।

रेतीले बनाना।

नीर समय १—साधारण उर्ध्वस्थ पहने तथा पूरा फूलों से विदेश करनी गणचिह्न है।

नीर समय २—सिरों का जलाशय निर्माण किए गए बुध वर्ष का निर्माण करने हेतु प्रामाण्य वहीं है।

साधारण उर्ध्वस्थ समय की एक हजार के एक सय पूरा फूलों निर्माण करना गणचिह्न है।

(१) तब संयोग सिरों की पशी।

(२) तब भवताप, गृह वा गुरुशास्त्री।

(३) भूमि की गुणधर्म।

(४) गोरियों का धारण।

(५) शरीर रूप से अति स्वास्थ्य का निर्माण।

नीर समय ३—वेचों की संकल्पना का उल्लेख निर्माणित विषय कर्जर नागार निर्माण करना पादस्त्र।

(१) हलका।

(२) फलों रूप।

(३) मलेर संहार।

(४) निर्माण रूप अति हलका।

नीर समय ४—साधारण उर्ध्वस्थ में रहना।

(१) स्वाभाविक जलवायू सिद्ध।

(२) वाली समय ५।

(३) वाली समय ६।

(४) संसार बुध।

(५) निर्माण रूप।
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<th>जन्म तिथि</th>
<th>निवासस्थल</th>
<th>माहिती</th>
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### APPENDIX III.—BIBLIOGRAPHY.

<table>
<thead>
<tr>
<th>Author</th>
<th>Name book</th>
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<tbody>
<tr>
<td>2. Champion, H. O.</td>
<td>Indian Forester, Volume 1, page 445 Good production of Pine mopped for (text).</td>
</tr>
<tr>
<td>3. Dhillon</td>
<td>An investigation of certain factors concerning the milled-tapping industry in Pinus ravennae (Forest Rivalry No. 11, 1926).</td>
</tr>
<tr>
<td>5. Gillies, A. J.</td>
<td>The development of the milled-tapping industry in Germany during the war. (Pages 723—811) of Our Indian Forester, Volume XLIV, for October, 1930.</td>
</tr>
<tr>
<td>6. Perry, Groom and W. Haddon</td>
<td>&quot;The structure of the wood of the East Indian Species of Pinus&quot; (Communication 1st May, 1911).</td>
</tr>
<tr>
<td>8. Schröder, H. S.</td>
<td>&quot;The structure of the wood of the East Indian Species of Pinus&quot; (Communication 1st May, 1911).</td>
</tr>
<tr>
<td>9. Schröder</td>
<td>&quot;The structure of the wood of the East Indian Species of Pinus&quot; (Communication 1st May, 1911).</td>
</tr>
</tbody>
</table>
TECHNICAL ORDER NO. 14.

Road Construction.

1. Roads are made in order to facilitate the carriage of passengers and goods from place to place with the least expenditure of motive power consistent with economy of construction and maintenance. The traffic can pass easily over some gradients or longitudinal slopes, on the road, but is checked by others. Over a rough country the tracts made by the inhabitants for themselves and their cattle are as direct as possible, but they have to deviate from the straight line where they have to encounter ground which slopes at an angle steeper than men or cattle can negotiate. Also considerations of gradient compel a deviation from the direct route.

2. In the layout of a road two principal points must be considered (a) the line or direction in the horizontal plane, and (b) its gradient or slope, i.e., its direction in the vertical plane. The first consideration in laying out a road connecting two points is that they should be joined by the shortest route; and if this does not involve too steep a gradient, a straight line between the two places, the road has to join, would be the best alignment of the road. In the hills, however, this is seldom possible as a straight road may need steep gradients or deep cuttings or high banks where valleys have to be traversed. So in hills it is generally better to go round a hill than straight over it, for in this way easier grades can be secured, but easier may arise in which it would be better to improve the gradient on a straight road by excavation as the main idea is to avoid too lengthy a road as well as to avoid the exertion of animal power. It is also advisable to carry a road into low lying land where high banks are necessary, if by a moderate deviation it can be run on to ground where good gradient can be secured. As a matter of fact, such gradients are more important than a badly graded direct route, a fact which must always be borne in mind, but at the same time, excessive length must be avoided for if there is any unnecessary increase in the length of the road, time will be wasted in travelling over it, and there will be unnecessary expenditure on its construction and maintenance. Within certain limits the
or ascent is more objectionable than extra length, since ascent reduces the carrying or tractive power of every pack or draught animal using the road. So much so that it is generally considered to be permissible to lengthen the road by 20 feet for every foot of rise or ascent thereby avoided. This, however, applies more to roads which are much used, generally it is best to make the track as short as possible, and consequently at the gradient permissible for that particular type of road. The ruling gradient of a road is the steepest grade that occurs in it, since it rules the maximum load that vehicles or pack animals can carry along it, i.e., animals drawing a load can traverse for short distances by expending about double the energy that is needed to move the same load on the level. This is called the ruling gradient, or the limiting gradient. For a horse can draw a load of 1 ton on the level, it can only carry 3 1/4 ton up to a gradient of 1 in 40, and only 3 ton up 1 in 25 and 4 ton up 1 in 10, so that on a road which has 9 miles of 1 in 20 and 1 mile of 1 in 10, the maximum load that one horse vehicle will be able to take along that road will be 4 ton, and no more, i.e., the maximum load being fixed by the maximum or ruling grade of the road, 1 in 10 in this case. It, therefore, followed that it is useless to lay out a road for a greater part of its length at an easy gradient if a steep gradient has necessarily to be used for a portion of its length. It is better in such cases, if possible, to lay it out at one uniform slope (between the two gradients) for the whole length. For instance in the above case the road with 30 feet at 1 in 30 and one mile at 1 in 10 might be laid out the whole 10 miles at a uniform grade of 1 in 25 (the total rise would be the same in either case), and 1 in 25 being the ruling gradient now instead of 1 in 10 every horse vehicle using the road could take 4 ton in place of 4 ton presently; an obvious advantage as the capacity of the road is at once doubled. In laying out a line of a road in the hills there are three cases which may have to be treated. First, two places to be connected may both be situated in a valley and upon the same side of it, that is, they are not separated from each other by the main stream which drains the valley. This is the simplest case. Secondly, though both points are in the same valley, the two places may be on the opposite sides of the valley, being separated by the main river. Thirdly they may be situated in different valleys, separated by an intervening ridge of ground more or less elevated. In laying out an extensive
line of road it frequently happens that all these cases have
to be dealt with and each will have to be treated on its
merits for the numerous and diverse circumstances
with in the construction of roads are such that no definite
rules can be laid down to embrace all cases. The main
idea should therefore be to avoid any unnecessary rise and
it is a very bad fault for a road that must ascend from A
to B to descend even for a short distance between A and B
thereby adding a rise to be negotiated. (Diagram).

3. The fault of switch back grading is a very com-
mon one in village hill tracks, which descend into almost
every nullah they cross, only to ascend again on the other
side. It should be a general rule that a road ascending
from one point to another should usually not ascend even
for a short distance between those two points. This how-
ever cannot always be done owing to the great increase in
length which would take place, when the points to be
connected may be situated in different valleys. So if the
road, when laid out at an even grade between two such
points B and C is found to be obstructed by cliffs, etc.,
which it is desirable to avoid, rather than descend from C
to D in order to do so, it would be better to lay out the
road at a slightly easier grade from A to D so as to pass
under or above the cliffs at D and then to make it a slightly
steeper gradient from D to B, the road would thus avoid
the whole of the way. Switch-back grading shows bad
work by the person who lays out the road. However
consideration will show that the choice of a road align-
ment, while depending on principles stated above, re-
quire judgment and the exercise of much common sense.
In level country there are not, as a rule, many alternative
routes between two points, but in hilly country there may
be several. One line may give good gradients but may
prove to be too long, another may be more direct but may
have to descend after a long ascent. The main object
should therefore be to eliminate the superfluous rise and
yet to secure as direct a route as possible without great
cost.
4. The gradient on those portions of a road which have to pass through solid rock on the face of a vertical precipice will ordinarily be level or as near level as possible. On sharp bends and at turns it may be required that the gradient will be as level as practicable.

5. It sometimes can be foreseen at the time of alignment that an inspection path will eventually be converted into a bridle path, or a bridle path converted into a cart road. In such cases an inspection path will be aligned throughout with a gradient suitable for a bridle path; while a bridle path that will probably be converted at some later date into a cart road will be aligned on the gradient for a cart road.

6. In order to localise out-breaks of fire in forests it is necessary to sub-divide forests by means of contour paths about a third above or below the lower or upper boundaries with connecting links down prominent spurs.

7. These contour paths will serve to localise out-breaks of fire, and to enable labour gangs quickly to reach the sites of fires; they will also serve as inspection paths. The width of these contour paths should be 3 feet except on very rocky surfaces where it may be reduced to 2 feet.

8. The maximum or ruling grade is settled before a road is made to suit the traffic that will use it. The ordinance for making the road always specify the ruling gradient and the clear width, besides any other important points that may be required.

9. The maximum (steepest) gradients that should be used for tracks in hills are as follows:

- Inspection paths: 1 in 4
- Path for laden mule teams: 1 in 5
- Briddle path: 1 in 7½
- Mule road: 1 in 10
- Camel road: 1 in 15
- For okkis or mule or bullock carts: 1 in 17

The above should not be exceeded.
10. The minimum width of the roads and paths in the clear should be:

For mule roads ........................................ 2 to 3 feet.
For riding or pack mules (unimportant tracks) .............. 4 feet.
For pack mules or ponies (important tracks) ................. 6 feet.
For pack mules or ponies at passing places ................. 12 feet.
For camels or oklas, single line ............................ 8 feet.
For camels and oklas, at passing places ..................... 16 feet.
For mules and bullock carts ............................... 18 feet.

11. Where possible fields and cultivated land should be avoided.

12. Contours and gradients.—A good map is of great help in the choice of the preliminary line of a road and if the map is a contoured one a good deal of work in the field will be saved. Contours are lines of equal altitude and represent imaginary lines running round a hill, or a valley, or a lake, at the same level. In the same plane, these heights being indicated by the figures written on the lines. The vertical intervals between the consecutive contours are equal. The horizontal distance apart of the lines representing them depends on the slope of the ground. When two lines are far apart the slopes they represent are easy; when they are close together they represent steep slopes. Contour lines, by their greater or smaller distance apart on a drawing, have the effect of standing and show at a glance ridges, spurs, drainage lines, steep slopes, and easy slopes. The heights of points on the drawing can be calculated by counting the number of contour lines from any convenient level when the contour heights are not at all marked in
figures on the plan. The difference in level between two places is found by multiplying the number of intervening contours by the vertical height between contours. A rough sketch of a road at any gradient can be marked out rapidly on a contoured plan. For instance, if the contours are at 5 feet interval and the gradient is 1 in 30 or 5 in 150, it is necessary only to separate the points of a divider to a distance apart representing 150 feet on the scale of the drawing to place one point of the divider on a contour line, and the other on an adjacent contour line, and a trace of 1 in 30 is at once indicated. If it is necessary to ease the grade, this can be done by scaling off more than 150 feet on the dividers. In dealing with contoured maps it is necessary to understand the use of a scale of slopes. Gradients may be expressed by the difference in level which occurs in a certain horizontal length compared with that horizontal length, as for example, 1 in 20 or 5 per cent, or the slope may be expressed in degrees of elevation above a horizontal plane.

A slope of 1' represents a rise of one foot vertically in a horizontal distance of 57.3 feet and so for 2', 3', 4', 5' and 6' the distances are 28.6', 33.1', 33.3', 33.4' and 33.5' respectively. For all practical purposes of rough calculations—

\[ -1' \text{ is equivalent to a slope of 1 in 60.} \]

\[ 2' \quad \text{Do} \quad 1 \text{ in 30} \]

\[ 3' \quad \text{Do} \quad 1 \text{ in 20} \]

\[ 4' \quad \text{Do} \quad 1 \text{ in 15} \]

\[ 5' \quad \text{Do} \quad 1 \text{ in 12} \]

\[ 6' \quad \text{Do} \quad 1 \text{ in 10} \]

and so on.

13. From a contoured plan a longitudinal section can easily be drawn along any given line on the plan by
noting where the given line cuts the contour lines and setting up ordinates at these points on which the heights of the points can be marked, and connected by lines which will represent the surface of the ground. Roads in plains should not be quite level and they are made as far as possible with a minimum longitudinal slope for purposes of good drainage. The slope should be between 1 in 80 to 1 in 125 while it is easy to secure a minimum gradient on undulating country, or in country that has a natural uniform slope in the direction of the road, greater than the fixed minimum gradient. Case may arise where the slope of the country in the direction of the road is less than the grade of 1 in 125 indicated above. It would, therefore, be necessary in such cases, in order to secure a minimum gradient of 1 in 125, to make series of alternate slopes or reverse gradients. In these cases the minimum slope cannot well be worked to. The adoption of a minimum grade in a flat country such as the plains of India is not always practicable, but at the same time, long stretches of flat road should be avoided, especially in cuttings, for, while an approximately level road does not seriously affect traction, an accurately level road is either not properly defined or has, in towns, gutters and side drains which require to be made to slope to inconvenient depths below ground. Slight gradients maintain a better road surface than does a dead level, a result which is generally attributed to the better drainage on the incline. Moreover, on level roads the consumption of materials for repair, compared with that of a smaller length of road on a slight incline, and subject to the same amount of traffic, is some 15 to 25 per cent greater in the former case than in the latter. The cross slope of a road, from the centre to the edge, is intended to assist drainage, but as the road surface tends to wear into longitudinal ruts or tracks which interfere with this drainage, water lies on the road surface, where it is on a dead level longitudinally and damage results. Whether alternative slopes of slight gradient are less fatiguing to horses than a dead level is a matter on which opinions differ, but it is accepted that an approximately level road does not affect traction appreciably and drains better and costs less to maintain than truly level roads. Steep gradients on the other hand affect traction greatly and the question of maximum gradients is of great importance. This question is closely connected with the character of the road, its align-
ment, and the sort of traffic that preponderates in the particular district under consideration. Although a ruling gradient may be laid down as per above instructions for a road in a flat country, one may, be able to choose a cheaper and shorter line, and yet may, not be obliged to adopt gradients nearly as steep as the ruling gradient except in special places such as for example as some bridge approaches.

14. Before deciding on the alignment of a road in the hills, the Range Officer should get a good contoured map and study it carefully, and see if he can mark on it the general alignment he would select, assuming that there is nothing in the geological features to prevent the adoption of this line. He should then go over the ground to see whether the line could be followed. He should be accompanied by a subordinate whose earnestness will be great if he has a good eye for country and has previously been employed on work in the hills. Together if ey should study the locality, examine the suggested alignment, see if it leads them into difficult situations, try alternative alignments if it does, and fix on obligatory points which the road or path must pass through. No map can make up for personal knowledge and the more thoroughly the reconnaissance is made the better will be the final survey and the alignment. Sometimes the first reconnaissance has to be made in new country to ascertain the relative heights of the hills that the road must cross. Geological features should be carefully noted, existing and old established lines should not be hastily abandoned, the question of water supply should also be examined and if the alignment chosen appears possible, the Range Officer should proceed to mark it out on the ground.

15. The De-Lisle Level or clinometer, is much the best on the whole, especially for rapid work. In rough ground, Abney's level is perhaps the best instrument for both surveying and road work. Clinometers may be divided into two classes (a) those which depend on the spirit level, i.e., the Abney Level and (b) those which utilise the principle of the plumb bob such as De-Lisle Level and Watkins Clinometer. Generally speaking class (a) is more accurate and class (b) less liable to breakage, and better for road work. A simple road
tracer, which can be made by a carpenter, can also serve the purpose.

16. The particular instrument to be used having been chosen, and tested to see if it is correct, the following will be found the best, quickest and simplest way of marking out the line of hill roads on the ground. This system has the advantage that both the line of the road as regards direction and its gradient (and therefore its level at every point of its length) are both given by a single operation and by the means of one line. In this method the line marked out is not the centre line of the road, but the outer edge i.e., the line where the road cuts the surface of the hill side.

The observer and 6 men are required for this work.

17. It will be convenient to use a sight rod with a sight vane (this consists of a straight light rod or bamboo with a cross piece nailed on it at the height of the observer’s eye), especially for bushy or jungle country where it is often difficult to see a man when taking a long shot. The best form of sight rod is about 6 ft. long by 14 inches square; the sight vane being a piece of board about 12”×9” which slides up and down the rod and can be clamped at any convenient height, so as to suit the observer (the 12” side of the board being horizontal); the board is painted black with a 2” wide white line horizontally across its centre; for use the board is clamped so that the top edge of the white line is at the height of the observer’s eye. It is well to have two sight vanes and rods for quick work. There should be two men with each sight rod. In addition it is necessary to have a couple of men carrying white wash as the marks, when whitened can very easily be picked up afterwards when working parties are strung out on the work. In bushy country 2 to 4 men, or more will be required to clear the line of sight.

18. Opinions differ whether the work of aligning the roads should be started up hill or down hill. Some are of the opinion that the work should be started up-hill, especially if the country has not been gone over before, as the nature of the ground can then be seen in front and any precipice or bad ground better avoided than when working down hill. But others incline to the view that
the work should begin from an obligatory point on the top of a hill, e.g., a pass through which the road must go, and work down the spur which had been selected after the first reconnaissance, putting in pags at 100 feet apart, or 60 feet apart, or at smaller intervals according to the configuration of the ground and connecting them by a "ditch" i.e., a narrow trench) in the ground. The reason in this case for starting work at the top of a hill is that the ground gets easier as the lower slopes are reached and deviations can be made to enable the road to reach any point in the valley, while these could not be made with ease if the observer worked upwards towards the pass. The chance in working up are that the road would be either too high or too low for the pass. In the former case, the grade could be eased, which would increase the length to some extent but in the latter case it would be necessary to make a zigzag. It is not always necessary to look for a pass as an obligatory point; for very often a hill can be "rueded" and the road may be able to go round it without being any longer than the road that would go over it, thus saving risse and fall, and even if it is somewhat longer, the alignment round the hill may be better than the other, assuming always that both roads are equally suitable in other respects, viz., which has the best shade, which passes a forest or village that must be near the road, which has the best water supply, which is the easier to maintain. These are questions for consideration. Others will be suggested by the circumstances of each case, but they will not affect the main fact that the survey should start from the highest point chosen and work downwards.

19. The observer should, as he proceeds, collect information as to the soil and the slope of the hillside at each station, and on the correctness of the information he acquires will depend the correctness of the estimate subsequently made. He should judge how much of the road width will be cut out of the hill side and how much will be in bank, for it may not be necessary to cut the full width except in a few places. He should note where retaining walls are needed and where the soil needs breast wall.

20. The Range Officer, if he can do so, get a subordinate who has an eye for country and with him he should make a preliminary reconnaissance of the ground.
traversed. The oftener he can go over it, the better. Perhaps his other duties will prevent more than one or two visits, but he should do his best. During his reconnaissance he should make as full notes as possible of every matter that may have a useful bearing on the project. If a good map is available he should mark on it points through which the road must pass as, for example, a part of a river suitable for a bridge or that the road should, if possible, avoid, such as valuable trees, and he should select one or more trial lines from which the final route will be chosen. He should then make a survey embracing the selected trial line and should record in his field book full details of existing roads, Railway lines, Canals, Irrigation channels that come across the selected trial line. He should locate all prominent points by Compass bearings where they are too far to be measured by offsets. He should also ascertain the level water level and the high flood level of all streams, or flooded land, the drainage area of streams, the slope of their beds and the nature of the soil. While doing so care should be taken to place the bridge at right angles to the direction of the stream, etc., when in flood, even if the road has to come on the bridge by a double curve. In fixing the alignment of the road he should take care not to introduce sharp curves into any part of it. The alignment should be marked at intervals by masonry pillars. Where the final direction of the road can be fixed upon in the field, or from existing maps, the traverse line of the survey may follow the centre of the road.

21. The observer stands where the road begins to ascend or descend the hill facing the direction the road has to take. He adjusts the instrument to the gradient which he means to use and clamps the index van to it. Having adjusted the sight vane to the height of his eye he sends two men with the vane along the hill to a convenient spot where they are visible to him; this will generally be at a spur, re-entrants or nullah. One man rests the sight vane on the ground facing the observer, who looks through the instrument and directs the man to move up or down the hill until he sees the horizontal line on the sight vane is opposite the reflection of his own eye in the mirror. He then signals to the sight vane holder who marks the spot where his rod rests on the ground, the second man with him drives in the peg firmly to mark it permanently, or
makes a heap of stones on the spot. The ground where
the sight vane rests and the ground under the observer's
feet now have the required gradient between them. (See
Diagram No. 38). The ground between should be ap-
proximately a straight slope as between A and B, where A
is the observer and B the sight vane; if there is a hollow
or re-entrant in the ground between A and B (such as C
between B and D), the sight vane must be sent to that spot
first and to B afterwards; as the road will almost certainly
be made too low at the re-entrant unless the working
parties have a mark placed there to guide them.

Diagram No. 38

A mark must always be fixed at every nullah or re-
entrant or hollow however slight, and every spur. Null-
ahas are especially important, as, if no mark is given in a
nullah, the road will of a certainty be made descending
into the nullah slightly and ascending to the next spur on
the other side. If there is a pronounced nullah running
into the nullah at E the further spur F must be fixed from
E in the nullah and not from D, as the straight line D F
would give a wrong gradient. It is most important that
spots in the ground determined by the instrument are so
marked that they cannot be shifted or lost, as these are
the only marks to guide the working parties afterwards; a
peg driven a foot into the ground with 6° sticking up is the
best, it is as well to heap stones or earth round it on which
to sprinkle the whitewash. The point B, being marked,
and the ground on which the observer stands similarly
marked, the two men with the sight vane are sent to the
next convenient spot C, and the observer still standing at
A directs the sight vane holder as before, until the sight
vane is in the line of the sight of the instrument and ap-
pears level with the observer's eye reflected in the mirror.
then the point C is similarly marked. This process is repeated till either the sight vane has got too far forward for the observer to see it distinctly or a spur, etc., prevents him seeing it, or a nullah comes between. For example, E is probably invisible from A; and F must be fixed from E and not from D owing to the nullah between D and F; when this happens the observer walks along the line to the last place D, where he has fixed a point, and standing at D, behind the pegs, he sends on the sight vane to any convenient spot E and fixes E from D just in the same way as he fixed B, etc., from A. He then puts on as many more pegs from D as he can (only one here on account of the nullah at E) and then moves forward again and stands at E, the last point he has fixed from D, and so on. He continues until the whole line is pegged out. The whitewash party follows up and whitewash the stones placed round the pegs. If on arriving at any point the observer sees that the road must go below a certain rock or cliff, he must look through the instrument at the bottom of the rock or cliff and if the line of sight cuts above this point, he must evidently lay out the road at a flatter grade till he has passed the rock; so he must therefore alter the index arm to the flatter grade required and go on laying out the points as before until he has passed the rock or cliff, when the former grade is resumed.

The second sight vane and mark come in useful to send on ahead in such places to make trial shots; or sometimes owing to such obstacles, it is found that the previous 4 or 5 points may have to be altered a little lower down the hill so as to get below an obstacle, when the second sight vane can be sent back to realign these marks, thus saving time.

22. The line of the proposed road must now be marked out with pegs at convenient intervals, i.e., up straight slopes not further apart than 50 yards or so, also in every important hollow or re-entrant and on every spur. The top of the ground at these points (and not the top of the pegs or heaps of stones) is the level of the road bed at those points, and the marks thus show both gradient and direction of the road. The pegs may be taken as the centre of the road or the outer edge. On very precipitous hillsides the pegs must be taken as the outer edge, and on flat country as the centre. In order to facilitate estimating, pegs or stakes 10 ft. long will mark every chain and
stakes 3 ft. long will mark every 10 chains. On the completion of the whole of the alignment, the surface of the ground will be spittocked or daggaed from stake to stake.

23. When the men of the working party are put on to the work, they must be shown the marks thus fixed and told that the top of the ground itself at the pegs (or under the stone heaped) is the level of the road bed, i.e., that the road must be cut inside the marks into the hill, and that the outer edge must coincide in level with the top of the ground at the marks. The final level of the road must be made by banking which must be undertaken by the officer in charge, who is also responsible for seeing that only the proper width is executed. It must be particularly impressed on all concerned that the marks must be left until the road is completed; if this is not done the road becomes an up and down affair which cannot be restored to its proper grade afterwards, and without the pegs it is impossible to check who is at fault and the quantity of work done.

24. If possible, before starting get on a hill opposite the one on which the road is to be constructed and study it with field glasses if available. It is then possible to see which line will probably be the best, where ravines, cliffs, etc., must be crossed and what places must be avoided, and how to do so whether by going above or below. Any such points and also passes or cols where the road must necessarily go are called ruling points. Then lay out the line as already described beginning at the bottom and working uphill if possible, as in this case it is easier to see bad ground in time and avoid it, than when working down from the top. Rocky ground must be avoided wherever possible, especially cliffs where the ground must be blasted out.

25. Whenever possible, zig-zags should be avoided; but they are very useful sometimes and do not matter for narrow tracks, especially if each return is long.

26. As a rule a road must be laid out with the Clinometer fixed at the steepest gradient allowed for that class of road, unless it is certain that the hill top can be reached with an easier one. It is a safe plan to begin with a ruling gradient from the very beginning, only easing it where absolutely necessary to pass under obstacles.
Where the hill is very steep and high, and the top will only be reached by keeping the maximum possible gradient all the way, the shots taken with the instrument when laying out must be kept short so as to follow the curves of the ground closely, and long shots from spur to spur must be avoided.

27. In the preceding instructions on the alignment of roads the minimum width of road and path beds are given. In a road round a hill the cross section should have slope inclining inwards, with a ditch on the inside; this to prevent the road being washed away at its edge (which often has to be built up), and to avoid the danger, especially in turning a corner, of the passenger falling over the parapet. So if drain is to be made along the inside the width must be increased from 1 to 2 feet to give room for the drainage water, flowing from the hill above, also intercepted by the ditch on the inside, which has cross-drains at intervals leading under the road way to the face of the cliff. It is very important for roads 4 feet wide (riding and leading mules, etc.) to see that the width is nowhere less than the width laid down, and that no stones, or roots, etc., are left sticking out of the bank on the side which may catch in the loads used by mules and camels especially; all sharp stones must be removed from the road bed. On the whole on the slower types of roads it is better to omit the drain and give the road bed a slight slope outwards, making the outer edge 1 inch lower than the inner. The advantage of this method is to save the excavation of the extra width of the inside drain. The disadvantage of providing the inside drain is that when the slightest fall of earth slips from the hill face on to the inside of the road, it frequently clogs the drain, and the whole of the water in the drain floods across the road, often cutting it very deeply. If in any case the road is made with a side drain the water in the drain must be carried across the road at frequent intervals by cross drains, Irish bridges, or culverts, etc., so as to empty the water down the hill; there must be a cross drain at least every 50 yards. The road surface must slope in towards the side drain at a slope of 1 in 30. If the road is 16 feet wide and over, it must be barrel shaped. The best place for cross drains are at spurs, and not in small re-entrants, because at spurs there is more natural hard ground below the edge of the road for the water to wash away before it can cut away.
the road, the slope of the natural ground will be more gentle also, while at a hollow or re-entrant the ground will usually be at a much steeper slope than on a spur. Where a nullah crosses the road, there must necessarily be a culvert or Irish bridge, so that the side drain can run into the nullah itself at such places above the culverts. Where there are zig zags, the side drains must be run out on the natural ground slope at the ends of the straights, if the straights are long, more than 300 feet, cross drains must be added between the turn.

28. The side drain must be made straight, or in large radius curves and with no sharp turns in it. No roots or stones should be left in it, nor should it be taken round any stones or roots, such stones must be removed by blasting if necessary. The drain need not follow the exact foot of the inside or hill face of the road; very often in rocky places, the road may, be wider than necessary for a few feet, the side drain can be cut straight across such a place; provided the full width exists between the drain and the road. The side drain must be made 8" to 6" deep and from 9" to 2 feet wide. The cross drains, if open, must be paved with stones, about 4 to 6 inches below the level of the road; the sides must slope gently down to the centre. Where nullahs cross the road Irish bridges must be constructed. These are depressions lined with paving stones made in the road to a depth of about 12 inches depending on the size of the nullah. The paving must be from 4 to 12 feet wide. On all such bridges it is advisable to construct a drop wall on the down stream side, the wall first being made of dry stones, and the paving then added, the wall prevents the paving being washed away.

29. If covered cross drains are required, provided that plenty of large flat stones are available, very good ones can be made in dry stones without mortar up to spans of 6 feet or so, by giving a joint of 6 to 8 inches, these are fit for light cars. These drains must always have a paved floor carried out, well beyond the edge of the road, also a drop wall on the down stream side of the road must be provided. Some time a catch water drain is also constructed on hill slope considerably above the road, to intercept the drainage and lead it to ravines and water-courses.
30. When however, a road is carried through forests, the ordinary bevelled surface of the road may be adopted with small cuts from the outer drain at every 30 or 40 feet, until the hill side being carried away by the drainage, but on the hill side which are bare such a section would be unsuitable and a slope inwards should be given, more or less pronounced according to the steepness of the side slope of the hill and to the nature of the soil.

31. Some do not share the views of providing inward slope to a hill road with a ditch on the inside. They consider the best section for a hill cart road to be one that has the entire slope outward with no inside drain. As a matter of fact outward slope can well suit bridle paths, the cost of maintenance of which is trifling. Where the rainfall is excessive and the soil is very bad a hill bridle path with an entirely outward slope and no inside drain is more easily and more economically maintained than with a section of inward slope with inside drain. A side drain may be necessary in places to lead away a spring from a soft part of the road, etc., but these are the only exceptions, which pertain to the general engineering of the road. A slope entirely outward is especially unsuitable where the sides are liable to slip. The inside drain is also contrary to one of the first principles of hill engineering, which is that if there is a smallest slip of a few buckets full of earth or even the collection of a few leaves which allow the silt to accumulate will choke the inside drain, when the accumulated water will of course down the road, causing much injury to the surface, and discharge itself over the edge in a strong stream, of course often at a weak place, will cut away the bank and destroy the retaining wall. So water should not be allowed to accumulate where inside drains are provided. As a matter of fact maintenance gangs invariably seek shelter during a heavy fall of rain, and it is during the actual falling of the rain that the clearest damage is done to a road. Ten minutes after the rain has stopped the side drains are practically dry. The best arrangements therefore, are required to be made, where there are drains inside, to see that the road is kept properly drained during heavy rainfall. The outside slope is not even inconvenient for cart traffic. The tongues usually travel down hill at 10 and 11 miles an hour. Any danger that may be anticipated from the centrifugal force at salient angles
could not affect a vehicle until it was on the outside half of the road; and it would be immaterial whether the other (inner half) had a slope upwards or downwards. As a matter of fact, tough drivers prefer outward slope as they have only to look out for danger on one side whereas on the section of a road with inward slope they have also to take care to avoid the inside drain. An outside slope of 1 in 20 has been found to be the most suitable. When a road is made with an outside slope the following precautions have to be borne in mind for its proper maintenance, etc.

(1) The outlet at “A” in the Diagram No. 39 below, should be low enough to discharge the road drainage freely. This is often blocked by:

(a) The road wearing down in the centre.

(b) When slips are cleared away a lot of the spoil is left at the outlet and thus a bank is formed at A (as shown in dotted line) which obstructs the free flow of the road drainage.

Diagram No. 39.

(2) The earth from slips should be cleared clean away to the full width of the road, and not left banked up against the side of the hill at B, as the width of the road is thereby reduced.

32. When these precautions are not observed the road may assume the section shown by dotted line, when the centre of the road would become a watercourse and be thereby destroyed. The outlet “A” mentioned above refer to the 3 feet intervals left in the parapet walls to
pass the surface drainage. The parapet walls are usually built in lengths of 10 feet with 3 feet intervals. By this arrangement 3/16th of the parapet walling is saved, whilst they equally serve as outside fence or the parapets may be built in 7 feet lengths with 2 feet openings.

33. Another advantage of the outside slope is that the road is widened by the 3 feet required for the inside drain, or the width of the cutting may be reduced 2 feet in the first construction. As this is the inside 2 feet where the heaviest digging is required, the saving in the first construction would be great. Should the soil be strong and the rainfall moderate there is no objection, except so far as the great increase of cost is concerned, to making the road with inside drain but with an excessive rainfall or in bad soil liable to slip or be washed away there is no question but that from an engineering point of view, the outward slope should be adopted.

34. In view of the above before taking the work in hand Range Officers should obtain orders from Divisional Forest Officers on this point whether the road or path should be constructed with inward slope and a drain in-side or with outward slope and core drain. The Divisional Officer will decide in the following manner:

- Should the soil be strong and the rainfall moderate, there is no objection (except so far as the great increase of cost is concerned) to making the road with inward slope and an inside drain. But with an excessive rainfall or in bad soil liable to slip or be washed away, the outward slope should be adopted.

35. Walls built of stone or brick masonry, concrete or of a combination of any of these for the purpose of holding up water, are called dams. But when such walls are built to support earth and to prevent it from sliding, they are called retaining or revetment walls. Breast wall is a kind of revetment wall erected to protect the exposed surface of cutting from the deteriorating effects of the weather. Retaining walls are built with or without mortar.

36. In the Forest Department they are usually built of dry stones which are most useful (logs and sawn timber
can be used when crooked; they can be built very quickly by men accustomed to the work. In rocky places, or narrow awkward mullains where the ground is steep, their use enables blasting to be avoided, and in steep portions the road, in place of having to be cut in the hill, can be carried outside the hill surface with a minimum of excavation. Blasting, whenever possible, must be avoided, as it takes a long time, much labour, and is expensive. Dry stone retaining walls require great care in their construction, as their stability entirely depends on the accuracy with which the stones are laid and on the correctness of the bond. Unless the workmen are carefully watched they may make a good face while the filling and the backing may be laid carelessly and with unsuitable material. For such reasons it is a good plan to collect all the material required before the work commences, and not to allow the earth filling at the back to be put in till every foot of the work has been passed by the Range Officer.

37. The masonry in a dry stone wall consists of courses of roughly dressed large stones laid as alternate headers and stretchers with filling pieces as shown in the Diagram No. 40. Headers are marked $H$, stretchers $S$, and filling pieces $F$.

38. Before a retaining wall is built it is of the utmost importance that the foundations are correctly dug. The excavation must be level longitudinally, and in steep ground they must be stepped down horizontally. The foundations must slope inwards at 1 in 6 to 1 in 4, at right angles to the outer face of the wall. For dry stone walls the top must be 2-5" for walls up to 10 feet height and 4 feet thick for those over 10 feet high. The foundations must be taken down to solid material, safe from snow, frost and surface water. Solid rock may be cut level,
but it is advisable to slope it towards the filling. Foundations must be at least 1 foot plus 1/10th of the height of the wall, below ground. In high dry walls a band of stone in line should be given at intervals varying with the quality of the stone. A normal method is to give a 12 inches band for every 6 feet in walls over 12 feet high.

30. The back should be vertical and the front slope downwards at a better of 4:1, so that the bottom width of the wall will equal width at top plus 3 inches for every foot in height, or if \( W \) be the thickness at the top and \( H \) the height in feet, the thickness of the wall at the bottom should be \( (W + \frac{1}{2} H) \) feet. The volume of the wall is calculated as follows:

\[
\text{Width at top} \times \text{Height} \times \text{Length} + \frac{1}{3} \left( \text{Height} \times \text{Height} \times \text{Length} \right)
\]

31. Great care should be taken to see that there should be plenty of weep holes in the wall and the weepers are built right through the wall. As the weepers interfere with the bonding, the mason, if not looked after, will blind weepers few inches or a foot deep from the outside, and these cannot be rectified later on without pulling down the entire wall. A good precaution, therefore, in building such walls is to see that every weeper has been left in at a stick of the full thickness of the wall. When the Range Officer inspects the completed work, he pulls out the stick and tests the lengths of the weep holes.

(For details of construction of dry stone masonry walls see technical order on construction and repairs of buildings).

(For Details for blasting see technical orders on explosives).

41. It is essential that the work should be completed within the sanctioned estimate which involves the preparation of accurate estimates and careful supervision of the labour employed.

42. In order to control the expenditure, the officer in charge of the construction of the road will maintain a
record showing the sum sanctioned in the estimates for each section of the road, (which should not exceed 10 chains), and the expenditure incurred each month on each section. As soon as the expenditure on a section has reached the amount sanctioned in the estimates, no further work will be carried out on that section unless money is available from savings on other sections or unless additional sanction is obtained from the proper authority for increased expenditure on the road. Boards will be erected on the road at the commencement of each section on which will be shown the number and length of the section to which it relates and the expenditure sanctioned in the estimates, and after the construction of the section is completed, the actual expenditure is incurred.

43. A sample of the form in which the note book should be kept is attached (Appendix A); Column 3 alone should be written up when the aligning and chaining are being done, but as soon as a section is finished the remaining information required for the estimate for that section should be collected.

44. This is done by taking the slope of the hill, at right angles to the line of the road, at the beginning of each chain, in the following manner:

45. The 10' rod should be held horizontally, at right angles to the road line, with one of its ends resting against the hill side. From the other end, a plumb line should be dropped to the ground vertically, and its length should be measured; this length divided by 10, will give the slope of hill side.

The slope is recorded in Column 4 of the note book.

46. The nature of the ground is then examined throughout the length of each chain, and its average quality is estimated by its appearance on the line, or immediately above or below the line, or by means of small excavations. The quality is then entered in Column 2 of the note book, and the corresponding rate per 100 ft. of excavation is shown in column 1. In Column 5 is then entered the prescribed width of road, modified as far as may be necessary on account of special conditions, e.g., where the gradient is steep or there are snow slides, etc., the width must be increased.
47. Each day the information recorded in the note
book should be carefully transferred to an estimate form
(Appendix B). In this form:—

(I) the figures of column C are:—
the slope of the hill multiplied by half the width
of the road

(II) Those in column E are:—
the figures of column C multiplied by the width of
the road.

48. In column C the figures have to be written under
each chain concerned and they must be put in a new line
unless the width of the road and the rate for excavation
are both the same as in some previous chain. The cross or
sectional areas are written in Column E in accordance
with the rate for excavation. Totals are made for every
10 chains, and are transferred to abstract (Appendix C)
for each mile.

49. It will be seen that this system of estimating does
not allow for any part of the width of the road being obtained
by filling, i.e., the full width of the road has to be excavated.
When completed the road will therefore be wider than is required, but in small roads and hilly country the
excess will often be small, and where the slope of the hill
is steep will soon disappear by being washed away. Cutting
the full width of the road avoids the expense of building
retaining walls and of frequently repairing them; but
when excavation is more expensive than the building of
retaining walls, also where there are curves in nuisances,
retaining walls must be built, unless another suitable alignment can be selected which shall enable them to be
avoided.
### Appendix A

Showing an example of a field note-book used in making the alignment of a full section from the 20th to the 29th chain.

<table>
<thead>
<tr>
<th>Rate per Quadrant cubic foot</th>
<th>Quality of ground</th>
<th>Chain</th>
<th>Square ft.</th>
<th>Field</th>
<th>Width of road</th>
</tr>
</thead>
<tbody>
<tr>
<td>36.00</td>
<td>Hard sandstone</td>
<td>1</td>
<td>14</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>28.00</td>
<td>Hard sandstone</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>22.00</td>
<td>Sand (loose)</td>
<td>3</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>24.00</td>
<td>Disintegrating lime stone</td>
<td>4</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>25.00</td>
<td>Hard stone, (1/2 stone, 1/2 earth)</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>24.00</td>
<td>Nearly 1 stone, 1 earth</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>27.00</td>
<td>1 stone, 1 earth</td>
<td>7</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>28.00</td>
<td>Earth</td>
<td>8</td>
<td>20</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>29.00</td>
<td>Earth</td>
<td>9</td>
<td>10</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Note: (Gradual 1 to 12 except chains 6 and 7 of 1 in 5, snow slides common in chains 1 & 9. Retaining walls 12' long, 3' high in chain 7, 24' slings 18' in chain 9.)
## APPENDIX B
FORM OF ESTIMATE PREPARED FROM THE FIELD NOTE BOOK ON ROAD ALIGNMENT

<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaps</td>
<td>Chain number</td>
<td>Height of road</td>
<td>Length</td>
<td>Note</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**Remark:**
- Material required for surplus filling out.
<table>
<thead>
<tr>
<th>Chainage</th>
<th>0</th>
<th>1.3</th>
<th>2.6</th>
<th>3.9</th>
<th>5.2</th>
<th>6.5</th>
<th>7.8</th>
<th>9.1</th>
<th>10.4</th>
<th>11.7</th>
<th>13.0</th>
<th>14.3</th>
<th>15.6</th>
<th>16.9</th>
<th>18.2</th>
<th>19.5</th>
<th>20.8</th>
<th>22.1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4,000</td>
<td>4,000</td>
<td>1,520</td>
<td>810</td>
<td>650</td>
<td>850</td>
<td>700</td>
<td>850</td>
<td>700</td>
<td>1,000</td>
<td>4,000</td>
<td>4,000</td>
<td>1,520</td>
<td>810</td>
<td>650</td>
<td>850</td>
<td>700</td>
<td>850</td>
</tr>
</tbody>
</table>

Total excavation (× 10⁸ cft)

Add 25% cutting back in Rs 1–Rs 10

Total excavation for 10 chains cft.
TECHNICAL ORDER NO. 15.

AERIAL ROPEWAYS.

General Description of Aerial Ropeways. Aerial Ropeways are used for the transport of materials by carriers suspended from one or more ropes which take the place of the track in a railway.

There are two principal forms of ropeways:—

1. Double or Multiple Rope; consisting of stationary suspension (or track) ropes and moving control (or haulage) ropes.

2. Single Rope; consisting of a single moving rope to which the load is directly attached and so serves the combined purpose of suspension and control or haulage.

In both these types the loads travel continuously in the same direction. The haulage power can be derived from gravity only when the load has to be carried downhill; where uphill carriage is required, some form of engine power must be provided to pull the load.

2. The Donald Aerial Ropeway. The Donald Aerial Ropeway is strictly speaking a combination of these two classes. The carriage of the load is on the same principle as the first class, but in the returning of empty carriers with the moving control rope the second class is also employed, because the rope which merely serves as a control or haulage rope for the load actually carries the empty carriers uphill again.

3. The ropeway is ideal for use in such mountainous districts as Kuli where portability and low cost of installation are of primary importance, and where, owing to the precipitous nature of the country, the number of settlements that can economically be delivered to each ropeway system is small, and the distance from the forest to a suitable stream or river being comparatively short, the increased cost of installing the more expensive Double Rope or Single Rope types with through stations would
not be compensated for by the total reduced cost of operation. The country being very precipitous with projecting ridges, and deep re-entrants long spans of Donald Ropeway between two thousand and four thousand feet long can be installed to serve nearly every section of the forest. To install a ropeway of either double or single type say seven thousand feet long of such a type that the load would not have to be disconnected from the control or haulage rope, it would be necessary for the ropeway to be absolutely straight and therefore to support it at more frequent intervals. In addition, and in particular when angle stations are necessary, a very much larger factor of safety is required to obviate the possibility of breaks, since men are or may be working under the ropes at the angle stations. Heavier rope results in increase in capital cost and in costs for carriage to site, construction of terminals, installation, etc., while expert supervision is also necessary.

4. The ropeways may be either gravity or power operated. In the Punjab all are gravity operated, with the exception of Patriala ropeway and in this description gravity operated Donald Aerial Ropeways only will be dealt with.

5. The simplest Donald Ropeway consists of a single stationary track rope with an endless control rope placed vertically under it.

6. In the Himalayan forests transport can only be effected by machines, and as it is essential that ropes be light and portable, the single track is replaced by three, each one-third the weight of the single track rope. These lighter ropes are more easily tightened than the heavier rope, and at less expense. With three track ropes in use, loads are carried at right angles to the direction of the span which is a distinct advantage in launching and receiving on steep spams.

7. The three track ropes are placed parallel to one another in the same horizontal plane, the distance apart depending on the length of the load. The most convenient distance when handling B. G. Sleeper is 3 feet between ropes. The track ropes are supported at each end by simple wooden trestles. At the top terminal the track ropes are attached to an anchor log sunk five feet in the
ground, or to a tree or to an iron bar fixed in a hole drilled in the solid rock.

Tightening is most conveniently and economically effected from the lower terminal as the tension there is less than at the top terminal. Simple wooden whistles are used, the free or running end of the rope being attached to anchor posts.

9. The endless control rope is placed vertically under the centre track rope and six feet below it and travels round a grooved wheel or "sheave" at each terminal. The sheaves revolve in metal bearing blocks which are bolted on to horizontal wooden beams supported at each end by upright posts; the stress being taken by guy ropes tightened by turn buckle to any convenient anchorage.
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control supports</td>
<td>Cage</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posts</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Posts</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Track Whaleless</td>
<td>Drums</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Top pole</td>
<td>.1</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Bottom pole</td>
<td>.1</td>
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<tr>
<td>10</td>
<td></td>
<td>Posts</td>
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<td>11</td>
<td></td>
<td>Poles</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>Central Whaleless</td>
<td>Posts</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Drum</td>
<td>1</td>
</tr>
</tbody>
</table>

Note—Item 4, Axial reeling to be done by construction crew.
## Ropes and Fittings required for the Installation of

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description of Articles</th>
<th>Truck Ropes</th>
<th>Control Ropes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1&quot; circumference Wire Rope</td>
<td>3/4&quot;</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5&quot; circumference Wire Rope</td>
<td></td>
<td>1-1/2&quot;</td>
</tr>
<tr>
<td>3</td>
<td>For 1&quot; circumference Wire Rope U Bolt grip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>For 1&quot; circumference Wire Rope U Bolt grip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Eye Shaped Thinskins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Anchor Ropes 1&quot; circumference x 20'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Guy Ropes 1&quot; x 20'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Gray 1&quot; x 20'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Gray 1&quot; x 30'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Hooks of 1&quot; square iron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Tumbrels 1&quot; x 9&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Dog splices 8&quot; x 15&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Dog splints 8&quot; x 15&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Bolts, nuts, washers 3/4&quot; x 3/4&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Wooden Pegs 8&quot; x 12&quot; x 2&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Central grooved wheel with flange</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Central grooved wheel without flange</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Oil can 1/2 pt.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Track Rope.** Wire Rope 1" (inch) circumference, galvanized, flexible, of best Crucible steel, acid quality 6x7 construction. Lang’s Lay, hemp core, breaking strain 3.5 tons (80 to 90 tons per square inch).

**Control Rope.** Wire rope, 3/4 inch circumference ungalvanized, flexible, of best Crucible steel, acid quality 6x7 construction. Lang’s Lay, hemp core, breaking strain 1.5 tons.

The 1" circumference rope weighs 0.15 lbs. per foot, the 3/4" 0.10 lbs. per foot, so that the length of rope can easily be obtained by weighing it and dividing the weight by 0.15 or 0.10 lbs. according to the circumstance.

**Explanations of above.**

*Galvanized.* The track rope is stationary and should be galvanized as a protection against damp, despite the fact that galvanizing weakens it slightly.

*UnGalvanized.* The control rope runs over sheaves and if galvanized the zinc would quickly wear off.

*Flexible.* For our work we require flexible rope (see remarks on breaking strain below).

Of best Crucible steel. Crucible steel is a trade name for steel produced by the “Acid Open Hearth” process, and distinguishes this steel from the more expensive “Plough” steel.

*Lang’s Lay (sometimes called Albert Lay).* The strands are twisted in the same direction as the wires which, if it is claimed, affords a larger area to resist wear. Rope of this lay is not as flexible as of “Ordinary Lay” where the strands are twisted in the opposite direction to the wires.

**6x7 Construction.** This defines the structure of the rope, and means a rope of six strands of which each strand consists of seven wires (six wire twisted round a central one).

For the same diameter rope, the 6x7 has wires of about 84 per cent, greater diameter than the 6x19 hence it withstands surface wear better. Rope of this construction is not so flexible as the 6x19, which was previously used.
Hemp Core. The functions of the hemp core are to absorb and hold lubricant, and to act as a yielding cushion for the strands. This is particularly necessary when the rope is bent passing over a pulley or when the rope is stretched by the application of a load. The hemp core does not add to the strength however.

Breaking Strain. The quality of the rope cannot be judged entirely by the guaranteed breaking strain as this is largely a matter of tempering, since the isabelle strength may be increased in tempering but the wires made brittle and less flexible. We want a happy medium, both strength and flexibility.

Note: One should keep in mind that in testing for new rope manufacturers are not allowed to use hemp core in production, while steel wire core is specified.

12. Control Grooved wheels and their accessories. Control grooved wheels are of two kinds (i) with a projecting rim 2" wide for the hand brake and (ii) without rim. They are of cast iron 2" outside diameter, with either a replaceable liner forming the bottom of the groove or a detachable groove screwed on. The bevel type is that designed and manufactured by the Canal Foundry ofRotate. For the sheave with break rim, this type has six spokes of cruciform cross section and to date no case has occurred of the spokes breaking. The four spoke oval section type has not proved satisfactory for the sheaves with brake rim, the design being rather clumsy and a large number of spokes having broken in use probably due to the expansion of the rim by the heat generated by the friction of the brake acting on the rim. The weight of the Rookes is 15.8 pounds and four members are required for its transport.

13. The Rookes grooved wheel without the projecting rim has a curved oval section spokes 2-1/2" section and this seems to be very satisfactory. The spindle or axle diameter has been increased from 1/2" to 2" because on long spans the smaller diameter causes excessive axle wear and friction. The liner depth has also been increased from 3" to 4" as with the smaller depth it cannot be securely fixed.

14. Axles or spindles are of polished mild steel shafting fixed by key in the hub of the grooved wheel. In the past 1/2" diameter spindles have been used but in future
the diameter must be increased to 2" to decrease friction and wear on long spans. The Roorkee hub is 8" wide. The length of the axle will depend on the width of the bearing to be used; for 3" bearings, 12" axle, for 6" axles, 18" axle. Ends of axles should be bevelled to prevent bursting. It should be borne in mind that the axle is 1/16" less in diameter than the hub, so that the key must be a sliding fit to prevent the sleeve creeping along the axle when in use, thus exposing the key and permitting it to come in contact with the bearing brass.

15. Bearings are of phosphor bronze or gun metal bored solid and are held in solid cast-iron bearing blocks. In the Roorkee type the bearing brass is 5/8" thick and 3" wide, the block being 14" long X 3½" wide and the base about 1½ thick. Type previously supplied by other firms have %" thick bushes, width 3½ and 6½ block length 8½. With the 2½ diameter axle a standard type heavy service "Plummer block" should prove quite satisfactory and more economical and if such can be obtained blocks with cast-iron bearings, which are also self lubricating and adjusting will be the most efficient and economical.

16. It should be noted that %" diameter hold down bolts are not satisfactory as they are easily damaged and bent, so that a larger diameter bolt, say 1½" diameter is most economical in the long run.

17. Brake. The descent of the load is controlled by a semi-circular band brake acting on the rim of the grooved wheel; the brake being operated by a simple hand lever. The brake is for convenience usually placed at the unloading terminal as this ensures that the brakeman brings the load in gently, while he also can give warning if a load starts off before it is connected to the control rope. For actual breaking effect the upper terminal is better since the tension is greater here and consequently there is more friction between the rope and the grove. The band is of mild steel 1½" to 2½" thick by 2½ wide. The type manufactured by the Roorkee Canal Foundry is not absolutely satisfactory since the brakeman is behind the sheave and cannot assist in disconnecting the coupling "Y" and in connecting the returning empty carriers, while since he is directly behind the sheaves he may be seriously hurt if the control rope breaks. Diagrams of brake are attached.
18. Carriers. These are simple carriers of the usual type for such work, consisting of hanger, spindle and small grooved wheel, and will readily be understood from the attached Diagrams.

19. The grooved wheel is turned from mild steel bar being 6" diameter and 1½" wide at hub. The hanger passes over the top of the grooved wheel and supports the spindle at both ends; it is made from 2"x3/8" or 3/4" mild steel flat bar, the latter thickness being better. Spindles are made from mild steel round iron bar. To start with they are used 3/4" diameter and are replaced by larger diameter spindles to take up wear in the hub of the grooved wheel. Patches may be riveted on the side of the hanger and may be replaced when wear has become great. Weight of complete carrier 1½ thick iron with patches is 6½ seers. Carriers supplied by the Rock Creek Canal Foundry and are of 3/8" thick iron and patches are not added, so that if these are required it should be specified in the order.

20. For a very flat span where the weight of the returning empty carriers is the controlling factor, a simpler and lighter type of carrier can be made in which the hanger does not pass over the top of the grooved wheel but is fixed to one end of the spindle. These carriers are more liable to jump off the track and the speed must be very carefully controlled.

21. Track Supports. The track ropes are supported at both ends by simple wooden frames consisting of two posts sunk five feet in the ground supporting a horizontal pole called a cap or transom. Struts or guys are added to prevent the posts being pushed over or shaken.

22. Track Anchorages. At the top terminal the track ropes are anchored by "U" Bolt Grips to a log sunk five feet in the ground, or to a substantial tree, or a 2" diameter round iron bar securely fixed in a hole drilled in the solid rock.

23. Track Tighteners. Tightening is usually effected from the lower terminal as the tension in the rope is less here, but if holes cannot be dug economically it may be necessary to do the tightening from the top terminal.

24. Tightening is effected by simple wooden windlasses 4½" girth by 2½ long with the projecting ends 4½ circumference which act as the axle or spindle. The drums are turned by removable wooden levers of the strongest
wood obtainable 6" circumference and 8 feet long which fit into sockets chiselled into the drums 3\*\times\times\times 5\* deep. There are four pairs of sockets and four levers are used in turning, two in front of the drum and two behind, two men working each lever. The windlasses are supported by inclined posts sunk full five feet in the ground and held by wire rope guys further to strengthen them. Care should be taken that the drums are so placed that the rope leaves the track supports in a straight line. One windlass is provided for each track. Other windlasses may be provided for tightening the control rope and getting it into position on the grooved wheels. Anchor posts to which the running ends of track ropes are attached are placed centrally in the rear of the drums.

25. Control sheave supports. The Control Sheaves are supported by two parallel horizontal wooden plates of 6" side of square section sawn true and kept 5\* or 0\* apart by timber dogs or wooden blocks and bolts. They are supported by vertical posts sunk 5\* deep in the ground the usual five feet. The joints are fixed on and morticed, and 7/8" diameter bolts and nuts are used. Care should be taken that the surface of the two parallel horizontal wooden plates supporting the bearing blocks are exactly in the same horizontal plane so that the axle of the sheave is truly horizontal.

To take the tension of the control rope off the post a "Y" shaped wire rope guy, in which is inserted a turn buckle, is taken from hooks on the bearing blocks to the track anchor log, the turn buckle being used to shorten the guy and pull it in tension.

36. Angles between terminals and lengths of spans. The longest and steepest spans so far used was 4,000 feet long, at a grade of 48 degrees with the horizontal between terminals. This is the limit in length. The lowest angle of grade has been 17 degrees on a 2,500 feet span. One span 4,000 feet long at 18 degrees grade worked but the load had to be pulled by hand into the terminal for the last two hundred feet and the factor of safety was only 15, so that this grade cannot be recommended for this length of span.

The best lengths and grades for speed and economy are 2,500 to 3,500 feet at 22 to 30 degrees between stations.
27. Below are given grades for different lengths of spans which should be taken as minimum for economical working and reasonable life of rope:

<table>
<thead>
<tr>
<th>Length of span horizontal</th>
<th>Minimum angle of line from top terminal to bottom terminal with the horizontal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet</td>
<td>Degree</td>
</tr>
<tr>
<td>1,000</td>
<td>15</td>
</tr>
<tr>
<td>2,000</td>
<td>17½</td>
</tr>
<tr>
<td>3,000</td>
<td>20</td>
</tr>
<tr>
<td>4,000</td>
<td>22½</td>
</tr>
</tbody>
</table>

28. Location of Ropeways and selection of sites for spans. This has of course to be done after the forest has been marked for felling. A very careful reconnaissance of the ground is necessary, time spent on this being well repaid by increased output and low installation and operating costs. It should be borne in mind that for most economical operations 900 cubic feet of scantlings should be roped daily and that the greater the total number of scantlings roped over a span the lower the installation cost per cubic foot. If spans are so located that only say 900 cubic feet can be extracted daily the cost is very considerably increased. Of course it often happens that it is not practicable to so arrange the spans or the crowns that 900 cubic feet are roped daily, as the increased distance of manual carriage to the ropeway or the precipitous nature of the forest may prevent this.

29. The following instruments and materials are necessary:

1. Almasy’s level—which should be tested to ensure that it is in order.
2. Flags, 6 red (or yellow) and 6 white.
3. Pair Field Glasses.
1. Contoured survey sheet including the forest of the largest scale available.

2. Indelible pencil for marking station pegs. Pegs can be cut in forest as required.

3. Hand axe for marking trees (optional).

4. Whistle.

39. Survey party. Two or three men as assistants to carry flags, cut pegs, etc. These should preferably be local men with thorough knowledge of the forest. The best guide should accompany this party. An official who has helped in the marking and knows exactly where the greatest number of scatings will be taken should accompany the officer making the selections.

A rough reconnaissance should first be made from some place such as the opposite hill side whence the whole of the forest to be worked is visible. With the help of the survey sheet alternate positions for spans can very often be chosen, the location of terminals being decided from the visible density of the forest, the configuration of the ground, and the survey sheet contours, lengths and grades being obtained approximately from the survey sheet. These stations should lightly be marked on the survey sheet with lead pencil. The spans so selected can then be examined on the ground, working from station to station, the actual grade being measured with the hand level. The sag of the rope at the center normally be between 5 per cent and 10 per cent of the length of the span and this must be remembered in considering whether the span will be sufficiently high above the intervening ground for the load to pass down and the empty carriers to pass up without coming in contact with the ground.

31. Erection of Terminals. This is best done departmentally by a trained construction crew working under trained subordinate. This work of course can be and has been done by the ordinary roping coilies on contract and the first cost is cheaper, but it is not satisfactory. Posts are not sunk to the proper depth, joints do not fit properly, bearings are not set on a level bearing, nuts
are put on bolts riding the thread sheaves which are not perfectly in line with the rope, and the journals of the axles are damaged in handling. All these faults cannot be noticed on inspection and it is not until roping starts and the rope-way is subjected to vibration, etc., that faults make their appearance.

32. It is, therefore, recommended that the work be done departmentally and the crew required is as follows:

One Forester in charge of construction.

One Skilled Carpenter such as is employed on bungaloo construction, with a knowledge of European tools and proper joints.

The ordinary village Tharikhan is not suitable.

Two Trained Collies who are good sawyers and expert axemen.

Local coolies according to the amount of unskilled labour necessary which will depend on the nature of the site.

A certain amount of blacksmith work will be necessary but this will not justify the whole time employment of a blacksmith and it can, therefore, be done by the man employed for general maintenance work at a central point, any article for repair being sent to him.

The felling and carriage of the timber required for each terminal can best be done by the local headguard. Detailed particulars have been given in the schedule of Material and Fillings Nos. 3 and 4 of the timber required. Installation of ropes can be done by the roping contractor, at the time of roping, but under the supervision of a trained subordinate.

33. Duties of the crew. The Forester will be responsible for the efficiency of erection and generally for supervising the carpenter and coolies.

The carpenter will do all the skilled work such as joints, and setting of sheave bearings. He will also set all posts and see that they are in alignment.
The two trained masons will assist the carpenter to
the best of their ability in all semi-skilled and unskilled
works when occasion arises.

34. Tools required for erection of terminals:

Four Scythes.
Four Pick axes.
Four Crowbars.
Four Jammers.
Four Pharwics.
Two Steel Wedges for splitting rock.
Two Axes (if skilled cooks do not provide their
own).
Two Hand Axes.
Two Foot Rules.
One Measuring Tape 50 feet.
One Spirit Level, Carpenters'.
One Oilcan, half pint capacity.
Six Files assorted, round, triangular, and flat.
Two Cold chisels ½" wide.
Two Sledge hammers, 10 lbs.
One Hand saw, cutting on the pull and not the
push.
Two Mortise chisels, one of ½" and one of 1".
One Plunger gauge 1".
Two Spanners, one for ½" and 5/8", and one for 3/4" and
7/8" bolts and nuts.
One Breast Brace, with bits long enough for cutting
1" deep.
Holes of width 1" and 2" (Augers are not satis-
factory.)
35. Actual Erection. The attached diagrams show the ideal position for the various members, and this should be adhered to as far as possible. The distance between the central post and the track support post, the track support post and the windlass or anchor log, is not important, and this can be varied according to the nature of the ground but the control sheave bearings must be at the proper distance from the supporting posts, the control support cap must be sufficiently high above the ground for the empty carriers to hang clear of the ground, and the track support cap must be at the proper distance above the control support cap. The control support caps must be between five and six inches apart, and a plumb line dropped from the centre track should pass midway between the two plates. The centres of the track windlasses should be exactly three feet apart, centrally in line with the position the tracks will occupy, and they should be at right angles to the span. Similarly the control rope windlass if used should be centrally in line with the control rope. The anchor posts should be centrally in rear of each windlass. All posts should be sunk the full five feet. The control rope guys as shown in the drawing should be taut. All joints should fit correctly.

36. Installation of Ropes. This as previously stated is best done by the roping contractor provided it is done under the supervision of a trained subordinate, or subordinate with no training or who is being trained having no more use than an untrained man.

37. The contractor's one subject will be to get the ropes in position for roping in the shortest possible time. He will be indifferent to damage done to the ropes from contact with jagged rocks and by kinks. An unculling windlass must be used for passing out the ropes as this is the only way in which kinks can be avoided. Any kink which cannot be straightened out should be cut out and the rope spliced with a twenty foot splice.

38. All ropes are first carried to the top terminal of the span. An absolutely straight narrow lane is then cleared from the top terminal to the lower by lopping interfering branches and falling trees. This lane should not
be any wider than is necessary to permit the first track to be raised from the ground and is best done under the super-
vision of the boat guard as this obviates the possibility of
friction between the subordinate in charge of the con-
struction and the range staff. One track rope is then laid
between the two terminals with the upper end attached to
the centre anchor log loop by a thimble and 8-U bolt grips
and the lower end given five turns round the centre truck
windlass, the rope of course passing over the truck supports
and not through them. The rope is then raised by the
windlass, eight men being employed on the windlass
levers, two to each lever and when in position the running
end secured at the anchor post by U bolt grips. In tight-
ening all ropes care should be taken to keep the rope between
the windlass and the anchor post taut as there is always the
possibility of one of the levers breaking which unless this
precaution is taken may result in serious injury to the
windlass crew. One track rope now being in position the
other two in turn are slaked down it, being supported at
intervals by forked twigs. When the lower end has been
passed round the windlass and the strain taken these twigs
are knocked off by a small piece of wood being allowed to
slide down the first rope. Both these ropes are stretched
in the same manner as the first and fixed securely. The
control rope will of course be double the length of the span.

To get it into position the two ends are sent down the track
ropes in the same way that the second and third track ropes
were and the loop thus formed at the top terminal passed
round the top control sheave. A special anchor rope is
then attached by a clew or U bolt grips, 10' from the end
so that the clamp or grips are adjacent to the control sheave.
If there is a fourth windlass for the control rope and this
is undoubtedly a convenience, the running end is then given
five turns round this and the rope is raised by the wind-
lass to its proper position, the forked twigs being knocked
off as in the case of track rope. If there is no fourth
windlass, the centre track rope must be clamped to an
anchor rope, removed from the windlass, and the control
rope raised to position by this windlass. A mark is made
on the control rope, at the control sheave for cutting for
the splice and the whole rope lowered to the ground by
reversing the windlass. The anchor clamp on the free
end is then released, the rope cut at the place marked for
cutting and the two ends brought together and spliced.
The control rope is now cut off, is in position on the top
sheave, and must be stretched and get in position on the bottom sheave as well. To do this a piece of rope about 20 ft. long is taken and each end clamped either by cramps or U bolt grips to the control rope leaving about 12 ft. of the control rope in between. The end of the control rope still on the windlass is attached by a thimble and U bolt grips to the added piece of rope and the control rope raised. The control sheave is removed from the bearing blocks, the control rope slipped over it and into the groove and the sheave replaced in its bearings. The control rope and the track ropes are now in position and the centre track rope should be returned to its windlass and the clamps removed. The brake is next placed in position and the leading and unloading platform made of sleepers built up in a track or crib. The span is now ready for roping.

39. Tools required.

For splicing—

One Cold Chisel for cutting rope ¾”.

One Hand Hammer.

Two Hand Vises ¾”.

Two Pilers 10”.

One Marine Spike 5/8” diameter tapering to a point.

One Knife for cutting hemp core.

One Copper or lead hammer, 2 lbs. for hammering rope over.

One Roll of Electrician’s Friction Tape.

For Removing Control Sheaves—

One Spanner ¾” and 5/8”.

One Spanner ½” and 7/8”.

40. Splicing. The splice should be at least 20 feet long. Tools required are hammer and sharp cold chisel, 3 pairs of strong pilers, steel marlin spike, a knife and a
pair of 3 lb. copper or lead mallets. A bench vice is convenient. To splice: (1) Overlap the rope 20 ft. or more, and mark centre of lay on each end with string or chalk.

(2) Unlay each end to centre mark, and cut off hemp core.

(3) Interlock the 6 unlayed stands of each end alternately and draw together until centre marks meet.

(4) Unlay a strand A from one end, and follow it closely with opposite strand 1 of other end, if laying it into the groove left open by A, and proceeding thus until about 12 inches of strand 1 are laid in, then cut off A an equal length and tie the strands temporarily in place.

(5) Treat similarly strands 4 and D, and so on for each pair of opposite strands stopping each pair about 1/5 of the length of splice short of the preceding pair.

(6) Bend the rope back and forth until all strands are set in place and have equal tension.

(7) Warp ends of strands with friction tape or strips of sheet lead, and straighten them.

(8) With the vice and pliers, untwist and open the rope at the point where the first pair of strands meet, cut the hemp core at the centre, draw it out slowly and follow it up with the strand to be buried in the centre until the latter occupies the core. Cut off the core at the end of this strand. In same manner treat the other strand of the pair, being careful that their ends do not cross over each other.

(9) Twist the pliers back to close up the rope, and hammer the strands with the mallet to fix them firmly in place.

(10) Shift the pliers and repeat operation at the other 5 pairs of ends, and the splice is complete.

41. A few hints on the use, handling and care of wire ropes something which must not be done, the reason what must be done:

(a) Do not uncoil like a manila or hemp rope.
Why It causes kinks, which leads to fractures of the small wires composing the rope. You cannot take kink out of a rope by pulling.

What to do Either unroll along the ground, or place the coil upon a real or an unrolling windlass and uncoil, if you have kink in your rope throw it out by throwing the rope the opposite way to the kink if possible.

Do not place a rope over, or round,

(a) the raw edge of a rock, or
(b) square piece of timber.

Why It causes fractures of the small wires.

What to do (a) If over or round the rock, place a jacket of small pieces of thick wood between the rope and the rock, (b) use round timber not less than 1 foot diameter.

Do not use knots.

Why When the knot pulls tight it fractures small wires.

What to do Give the end of the rope several turns round the anchorage and clamp it or bind it with wire to the standing piece.

Do not allow the end of the rope to remain unwrapped.

Why The strands of rope will work loose and several yards will quickly become useless.
What to do: Wrap the ends of all ropes, with thin wire about 2" from the end and finish your wrapping in the middle.

(c) Do not use a tourniquet.

Why: It fractures all the wires wherever used.

What to do: Tighten your rope with a drum, or ratchet pulley block (a stopper, which can easily be fastened to a rope to form a connection for a hook), or use clamps or U bolt grips which do no harm the rope.

(f) Do not make short splices.

Why: If in the carrying rope short splices cause the carrier to bump and will perhaps throw it off the rope. If in the control rope, they cause a bump when passing over the sheave. The strength of the splice depends on the friction between the strands.

What to do: Always make long splices and carefully thin them out, the overlap of each rope should be at least 10" giving a 20" splice.

(g) Do not allow the control rope to grind against the flange of the sheave.

Why: It will cause a raw edge on the flange, which will quickly cut the whole of your control rope and besides the rope is bent.

What to do: The control rope must run in the centre of the groove and be parallel with the rim.
(b) Do not have a control rope too tight.

Why... It causes unnecessary strain in the rope, which wears itself out very quickly and also wears out the grooves.

What to do... Unless there is danger of fouling the ground with loose ropes the sag of the control rope should be considerably more than that of the carrying rope. A tight control rope can only be justified when it is necessary for the carriers to clear the ground between stations.

(1) Do not tighten your carrying ropes more than is necessary to cause the load to run home. This refers to spans up to 20 degrees.

Why... The tighter your rope the quicker it wears out.

What to do... On spans up to 20 degrees the difference between angles of the top and bottom stations, and angle taken from the top station along 100' of carrying rope, should be not less than 5 degrees.

(2) Do not put up new ropes and at once pull them tight.

Why... Ropes must be allowed to stretch and all small wires to correct their tension after being coiled up. If you at once strain a new rope, you will stretch some wires and not others.

What to do... Allow new ropes to remain up 3 or 4 days, before being tightened. This will prolong the life of your rope.
(k) Do not forget to slacken all ropes after a season's work, or when not required for some months.

Why: It prolongs their life.

What to do: Slacken all ropes as much as possible. If the ground is dry and not used by traffic, allow the ropes to rest upon the ground except in rains or snow season.

(1) Do not forget to oil or grease all ropes, when first put up and also before monsoon and snowfall.

Why: To prevent rust which quickly eats into steel wires.

What to do: The control rope can easily be oiled or greased by being pulled round by hand power and the oil rubbed on with a rag. The suspension or track rope can be oiled when it is being put up; as the rope is payed out rub the oil on with a rag. When necessary to oil it after erection fix a tin on to the top of a carrier the tin having a small hole in the bottom immediately over the centre of the carrier wheel. When the carrier is on the rope with the same oil into the tin, and slowly load attached ready to start, pour over the load. The oil will fall on to the carrier wheel and as it revolves will be carried on to the rope. Do this to each rope in turn, and be sure the loads go very slowly each time.

(m) Do not work ropes with broken wires, even if the broken wires are cut off and twisted in.

Why: This strength of your rope is the strength of its weakest part, broken wires quickly become untwisted.
either by passing over the sheave, or by carriers passing over them. The longer you work a rope with broken wires, the more you will have to cut out when you splice it. If you work it with many broken wires, the remaining strands will be pulled out of place and you will damage the elasticity of your rope.

What to do: Cut your rope, take out the length with broken wires and re-splice it.

Why

1. It is very difficult to slacken your wires.

2. When a load is passing down the carrying ropes there is a slight endways movement, this will cause the overriding ropes to chafe one another and cause damage to the small outside wires.

What to do: Have no difficulty in preventing the pull of rope. You will then have no difficulty in preventing over riding.

(n) Do not allow the carrying ropes to override when passing round the drum.

(o) Do not have carrying ropes of unequal tension.

Why: The tight ropes will carry an unfair amount of load and become strained or wear out quickly.

What to do: Keep a sharp look out on your ropes, and if necessary tighten or slacken your ropes as required to keep them at equal tension.
(p) Do not use new and old ropes in the same span.

Why

The old rope has probably finished stretching while the new one has just commenced. It will mean adjusting your tension several times daily and will give unfair treatment to the new rope.

What to do

Each span must be composed of ropes of the same age and condition.

Kink

Twist in a rope formed by the rope being taken back and forward thus forming a coil which on being pulled distorts the rope forming what is called a kink.

Standing

Piece of rope. The end of a rope secured to some object, of that part not free.

Running end of a rope

The free end of a rope.

Whipped

One rope lashed or bound to another is said to be whipped.

Wrapping

Wire bound round the end of a rope to prevent it untwisting.

Touranquet

A simple lever placed between two adjacent and parallel ropes so that by turning the lever at right angles to the axis of the ropes they are twisted round one another and thus shortened.
Over-ride. When a rope is coiled on a drum and one coil crosses over another it is said to "over-ride".

Sheave. A wheel with a grooved rim for a rope to run in, the grooved wheel in a pulley block being a good example.

Flange. A projecting flat rim.

43. Loading and unloading Platforms.—Platforms are made of scantlings built up as a crib, no nails or spikes being used.

44. At the loading Terminal two are erected, one on each side of the central rope and about 4 feet apart to allow clearance for the arms of the coupling "eye".

45. At the unloading Terminal one Platform only is built and this is placed over the control grooved wheel, the span side being open. The advantages of the single platform are that a continuous platform is provided for the unloading coilers to work on, and if the brakeman is in rear of the grooved wheel, there is no chance of scantlings or carriages falling on him.

46. The construction of these loading and unloading platforms is most conveniently done by the roping contractor as part of the roping contract.

47. Dismantling of ropes and Fittings.—This is best done by the roping contractor, either at the conclusion of roping or when the ropes are to be transferred to a fresh span. This must, however, be done under the supervision of a trained subordinate, and there should be one such subordinate to each span being dismantled. Particular attention should be given to the coiling of the ropes in order that kinks may be avoided, and a coiling windlass should be used.
48. Transport of Ropes and Fittings.—A four thousand foot track rope will weigh six hundred pounds so that it is obvious it cannot be carried in one coil. The rope is, therefore, rolled on the ceiling in a number of bundles of coils, each bundle weighing 40 lbs. or say 20 seers, which one cooly load, about ten feet of rope being left between each bundle of coils for convenience in carrying. When the rope is being worked kinks may be formed between the bundles unless supervision is very strict. When the rope is to be transported a long distance a good way of avoiding kinks is to run a sucking round the rope between the bundles.

49. Loads.—A good normal load for the 1" circumference track rope is two B. G. Sleepers or say 6.2 Cft. or 263 lbs., but this may be increased to three B. G. Sleepers on occasions. A load of three B. G. Sleepers was the normal load on a span of 4,000 ft. with a grade of 18 degrees as with only two B. G. Sleepers the load did not run down to the unloading terminal. A load of two B. G. Sleepers can be launched conveniently by the despatching coollers, but with a heavier load the strain on the coollers arms becomes excessive for continuous working. The steeper the slope of the track the greater the proportion of the weight of the load thrown on the machinists arm in launching, and it must be remembered that only one arm is available as the cooly has to support himself with the other.

50. Capacity.—The most reasonable figure would appear to be 900 Cft. or say 300 coollings per diem. For a ten hour working day this means a load despatched every four minutes which is very reasonable for spans where the grade is such that the load runs into the unloading terminal without external aid. While one load is passing down the ropeway the next is being arranged and when the load comes to rest all that is necessary is for the coollers to be removed from the old load, placed on the control rope and the new load suspended from the track and coupled to the control rope these operations taking only a few seconds.

By increasing the load to three B. G. Sleepers and by increasing the number of coollers and the number of working hours daily the output can be increased of course, and is done for short periods but for normal working the figures in the previous paragraph should be taken.
51. Supervision.—Any officer or subordinate with a year's experience on the Donald Aerial Gravelly Ropeways should be in a position to supervise the work efficiently. In Bashahar, from 1924, twenty-seven spans were supervised efficiently by a staff consisting of a supervisor, an Overseer, and one Daroga per span, none of whom had previous training or experience in engineering works of any kind, under the supervision, of an Officer who had no technical engineering training. A tendency for officers and subordinates to regard this work as requiring technical training should be discouraged as it is not justified, because no great technical knowledge is required, but preliminary instruction and training should be carried out under a capable officer with experience of ropeway work. In past work the responsibility of ropeway work has been left too much to untrained Darogas temporarily employed for the purpose, but in practice it makes for more efficient working if the Range Officers are made primarily responsible for supervision, regulation of labour, and supply and replacement of damaged and worn posts.

52. Crew required to operate.—Scantlings are stacked near the loading terminal and are carried to the loading platform as required and the crew will depend on the number of cubic feet of scantlings to be roped daily. The number of men required to carry the scantlings from the stacks to the ropeway platform and from the unloading platform to the new stacks (or the next ropeway terminal if the ropeways are in series) will depend on the number of scantlings to be roped daily and the distances the scantlings are to be carried by hand. For the actual loading, despatching, receiving and unloading of the scantlings five men are absolutely essential and the normal crews for the operation of the ropeway may be taken as follows, provided the men are working on contract.

<table>
<thead>
<tr>
<th>NUMBER OF SCANTLING PER DAY</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
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<td>Crew required for the single span</td>
<td>6</td>
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<td>Crew required for each additional span if spans are in series</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
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In the above statement no allowance has been made for cooks, nor for time lost in fitting godown, etc.

Each crew should include at least one expert splicer and at least half of each team should be experienced rope-way men. The balance of each crew can be ordinary coolies accustomed to carrying scantlings as they will only be used for this purpose normally.

Assuming 300 scantlings or 900 cubic feet roped daily over an isolated span.

Manual carriage from stacks of previous span to platform 3 men.
Loading and despatching 2 men assisted by one of above three.
Unloading terminal.
Unloading, 1 man.
Brakeman 1.

Manual carriage from ropeway to stacks, 3 men.

Total 10 men.

For each additional span in a series the crew is reduced by two because the crew of the upper span deliver the scantlings at the loading platform of the lower span thus saving carriage from stacks to the ropeway.

23. Rules to be observed regarding loads and loading:

(a) No load should exceed 10 cubic feet.

(b) Equally divide the load on all three wires as far as possible when sending down mixed sizes.

(c) Launching should be done slowly and gently, because by suddenly throwing the weight of the load on the rope the strain in the ropes is enormously increased.

(d) The load should travel exactly at right angles to the ropes and perfectly horizontal. The
two arms of the "Y" coupling should be of
equal length and should be passed round the
load at equal distances from control rope. If
the load travels obliquely the carriers also
travel obliquely and the sides of the grooves
wear the track rope while in addition there is
more tendency for them to jump off the track.
(e) All three slings should be of the same length
and as short as possible; they should grip the
load at all four corners of the cross section of
the load.

(f) Slings should hang vertically under the track
rope.

(g) Slings and coupling "Y" should be made from
the thickest rope available.

(h) The height of the leading platform should be
so adjusted that it is necessary to pull the
track rope down to attach the slings to the
carriers.

54. Speed Braking, etc.:

(a) The rapidity of descent of the load should not
at any time be allowed to exceed 1,000 feet
per minute. The wear of the ropes and car-
riers depends almost entirely on the speed so
that provided the capacity of the ropeway is
not curtailed this should be kept as low as
possible.

(b) When the load is being placed on the ropes the
brake should be full on; as the brakesman can
then control the speed, and the full weight of
the load (that portion held by the control
rope) is not borne by the launching cooker.

(c) The brake should never be completely off
while the load is travelling down.

(d) Loads should be kept under proper control
throughout the journey and should be allow-
ed to come into the receiving terminal slowly
and gently. If the load is stopped with a jerk,
great strain is thrown on the control rope
and its supports which on long spans result in
the breaking of the rope.
(e) The brake blocks and the rim of the control wheel should be free from grease and blocks should be replaced before the screws are exposed as otherwise the rim will be damaged.

55. Maintenance and Repairs.—Repairs such as splicing ropes, replacing brake blocks, carrier wheels and spindles, should be done by the contractor working the ropeway as part of the roping contract under the direction of the formal subordinate trained in ropeway work responsible for the supervision of the roping. All other repairs such as reforming carrier hangers, replacing patches on carrier hangers, renewal or replacement of control wheel linings, replacement of worn-out bearing and control wheel cogs, etc., for which a trained blacksmith fitter is necessary should be done at a central workshop. A supply of spare parts should be kept in the neighbourhood of each ropeway system and when it is necessary to send any part to the central repair shop for replacement its place should be taken by one of the spares in reserve.

Normally one blacksmith fitter with a local blacksmith and four or five coochees to help him will be sufficient to maintain the fittings of twenty spans of ropeway.

Twelve carriers are required for the actual operation of roping on each span of ropeway.

56. Articles to be kept in reserve by the subordinate in charge of each system for the replacement of worn-out ones:

For each Span:

3 Carriers.
12 Spindles varying in size from \( \frac{3}{4} \) to \( 1 \) \( \frac{1}{2} \) diameter.
20 Washers assorted.
50 Split pins.
1 Oil can.

For each system:

1 Brake sheave complete with axle (spindle), key, bearings and blocks, and hold-down bolts and nuts.
1 Brake complete with necessary fittings.

Similar articles to be kept in Reserve for exchange in Divisional Store.
37. Roping costs.—The crews required for roping various numbers of sanctlings have been given. Knowing the daily earnings the average cooly may expect contract work and adding an allowance for the carriage of godown, if any, and cooking, and allowing one man per crew, the brake man, 30 per cent, higher wages, the cost per sanctling can be calculated without difficulty.

38. To estimate the all-inclusive cost of roping sanctlings.—In estimating the cost of extraction by rope-ways for comparison with other methods such as manual carriage, wet slide, head diving, either above or in combination, the total all-inclusive cost of extraction must be considered. The all-inclusive cost will include all costs such as:

(a) Cost of carriage of ropes and fittings from previous site to new site.
(b) Erection of stations and installation of ropes.
(c) Maintenance and repair of fittings, and oil.
(d) Operation costs.
(e) Dismantling for removal to next site and for an allowance for the depreciation of ropes and fittings:

(Carriage of ropes and fittings from previous site. One cooly can carry three hundred feet of 1" circumference track rope, and five hundred feet of 3" circumference control rope, nine coolies the sheaves and fittings, two coolies the carriers of one span. Knowing the length of rope required and the distance from the previous site to the new site this can be calculated.)
PROGRESS of AVERAGE DAILY COLLECTION PER 1000 BLAZES DURING THE SEASON

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DIAGRAM No. 05
### List of correction slips

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