

be maintained. More commonly there will be a succession of hills, part of the line up grade, part down grade. Sometimes there will be a continuous up grade but not at a uniform rate. With a uniform grade, a locomotive engine will be constantly exerting its maximum pull or doing its maximum work in hauling the longest train it is capable of hauling; there will be no power wasted in hauling a light train over low or level grades upon which a heavier train could be hauled. Where the grades are not uniform, but are rising or falling, or rising irregularly, it will be found that the topography on some particular 5 or 10 miles is of such a character that the grade here must be steeper than is really necessary anywhere else on the line; or there may be two or three stretches of grade where about the same rate of grade is necessary, steeper than elsewhere required. The steep grade thus found necessary at some special point or points on the line of railroad is called the "Maximum Grade" or "Hauling Grade" or "Limiting Grade". It being the grade that limits the weight of train that an engine can haul over the whole division. It should be the effort to make the rate of "Maximum Grade" as low as possible, because the lower the rate of

"Maximum Grade", the heavier the train a given locomotive can haul, and because it costs not very much more to haul a heavy train than a light one. The maximum grade determined by the Reconnoissance should be used as the basis for the Preliminary Survey. How will this affect the line? Whenever a hill is encountered, if the maximum grade be steep, it may be possible to carry the line straight, and over the hill; if the maximum grade be low, it may be necessary to deflect the line and carry it around the hill. When the maximum grade has been once properly determined, if any saving can be accomplished by using it rather than a grade less steep, the maximum grade should be used. The saving made will in general be one or more of three kinds; a. Amount or quantity of excavation or embankment; b. distance; c. curvature.

In some cases, a satisfactory grade, a low grade for a maximum, can be maintained throughout a division of 100 miles in length with the exception of 2 or 3 miles at one point only. So great is the value of a low maximum grade that all kinds of expedients will be sought for to pass the difficulty without increasing the rate of maximum grade, which we know will apply to the whole division.

Sometimes by increasing the length of line, we
are able to reach a given elevation with a lower
rate of grade. Sometimes heavy and expensive
cuts and fills may serve the purpose. Sometimes
all such devices fail, and there still remains
an increase of grade necessary at this one
point, but at this point only. In such case
it is now customary to adopt the higher rate
of grade for these 2 or 3 miles and operate
them by using an extra or additional engine.
In this case, the "huling grade" for the division
of 100 miles is properly the "maximum
grade" prevailing over the division generally,
the higher grade for a few miles only being
known as an "Auxiliary Grade" or more
commonly a "Pusher Grade". The train
which is hauled over the engine division is
helped over the auxiliary or pusher grade by
the use of an additional engine called a
"Pusher". When the use of a short "Pusher
Grade" will allow the use of a low "maximum
grade", there is evident economy in its use.
(Reference Wellington Eng. Theory Ry. Loc. Chap. XVI)

The Preliminary Survey follows the general
line marked out by the Reconnaissance, but
this rapid examination of country may not
have fully determined which of two or more
lines is the best, the advantages may be so

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nearly balanced. In this two or more Preliminary Surveys must be made for comparison. When the Reconnoissance has fully determined the general route, certain details are still left for the Preliminary Survey to determine. It may be necessary to run two lines, one on each side of a small stream, and possibly a line crossing it several times. The Reconnoissance would often fail to settle little points like this. It is desirable that the Preliminary Survey should closely approximate to the final line, but it is not important that it should fully coincide anywhere.

An important purpose of the Preliminary is to provide a map which shall show enough of the topography of the country, so that the Location proper may be projected upon this map. Working from the line of survey as a base line, measurements should be taken sufficient to show streams and various natural objects, as well as the contours of the surface.

The Preliminary serves several purposes:

- 1st. To fix accurately the Maximum Grade for use in Location.
- 2nd. To determine which of several lines is best.
- 3rd. To provide a map as a basis upon which the Location can properly be made.

4th To make a close estimate of the cost of
the work.

5th To secure in certain cases legal rights
by filing plans.

It should be understood that the Preliminary Survey is in general simply a means to an end and rapidity and economy are desirable. It is an instrumental survey. Measurements of distance are taken usually with the chain, although a tape is sometimes used. Angles are taken generally with a transit; some advocate the use of a compass. The line is ordinarily run as a broken line with angles. With a compass no backsight need be taken, and in passing small obstacles, a compass will save time on this account. A transit line can be carried past an obstacle readily by a zig-zag line.

Common practice among engineers favors the use of the transit, rather than the compass. Stakes are set at every "station" 100 feet apart, and the stakes are marked on the face, the first 0, the next 1, and so to the end of the line. A stake set 1025 feet from the beginning would be marked 10 + 25.

Levels are taken on the ground at the side of the stakes, and as much oftener as there is any change in the inclination

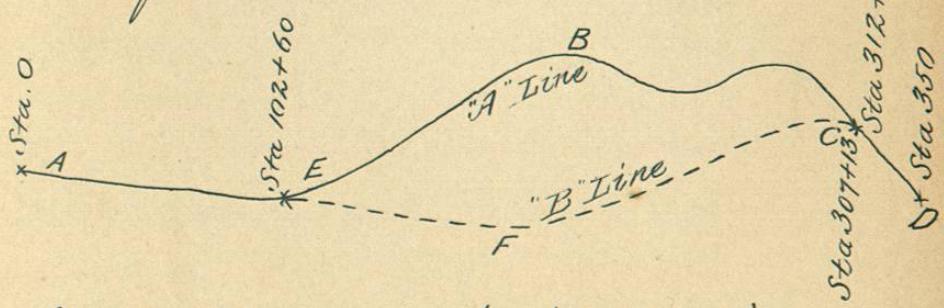
of the ground. All the surface heights are platted on a profile, and the grade line adjusted.

The line should run from a governing point towards country allowing a choice of location; that is from a pass or from an unimportant bridge crossing towards country offering no great difficulties. There is an advantage in running from a summit down hill, subject however to the above considerations. In running from a summit down at a prescribed rate of grade, an experienced engineer will carry the line so that, at the end of a day's work, the levels will show the line to be about where it ought to be. For this purpose, the levels must be worked up and the profile platted to date at the close of each day. Any slight change of line found necessary can then be made early in the next morning. A method sometimes adopted in working down from a summit, is for the locating engineer to plat his grade line on the profile, daily in advance, and then during the day, plat a point on his profile, whenever he can conveniently get one from his leveler, and thus find whether

his line is too high or too low.

Occasionally the result of two or three days work will yield a line extremely unsatisfactory, enough so that the work of these two or three days will be abandoned. The party "backs up" and takes a fresh start from some convenient point. In such case the custom is not to tear out several pages of note book, but instead to simply draw a line across the page and mark the page "Abandoned". At some future time the abandoned notes may convey useful information to the effect that this line was attempted and found unavailable. In general, all notes worth taking are worth saving.

Sometimes after a line has been run through a section of country, there is later found a shorter or better line.



In the figure used for illustration, the first line "A" Line, is represented by AEBCD,

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upon which the stations are marked continuously from A to D, 350 stations. The new line "B" Line starts from E, Sta 102+60, and the stationing is held continuous from O to where it connects with the "A" Line at C. The point C is Sta 312+27 of the "A" Line, and is also Sta 307+13 of the "B" Line. It is not customary to retake the line from C to D in accordance with "B" Line stationing. Instead of this, a note is made in the note books as follows:

Sta. 312+27 "A" Line - 307+13 "B" Line.

Some engineers make the note in the following form:-

Sta. 307 to 313 = 86 ft.

The first form is preferable, being more direct and less liable to cause confusion.

All notes should be kept clearly and nicely, in a note book, never on small pieces of paper. The date, and the names of members of members of the party should be entered each day in the upper left hand corner of the page. An office copy should be made as soon as opportunity offers, both for safety and convenience. The original notes should always be preserved; they would be admissible as evidence in a court of law where a copy would be rejected. When two or more separate or

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alternate lines are run, they may be designated Line "A", Line "B", Line "C" or "A" Line, "B" Line, "C" Line.

The Preliminary Line is occasionally run with curves connecting the straight stretches, generally for the reason that a map of such a line is available for filing and certain legal rights result from such a filing.

Organization of Party in Preliminary Survey.

The organization of party may be as follows:-

1. Locating Engineer.
 2. Transitterman.
 3. Head Chainman.
 4. Stake man.
 5. Rear Chainman.
 6. Back Flag
 7. Men men (one or more)
 8. Leveler
 9. Rodman (sometimes 2)
 10. Topographer
 11. Assistant
 12. Cook
 13. Teamster
- Transit Party.
- Level Party.
- Topography Party.

1. The Locating Engineer is the chief of party, and is responsible for the business management of the camp and party, as well as for the conduct of the survey. He determines where the line shall run, keeping ahead of the