CANADIAN PACIFIC RAILWAY COMPANY.

RULES FOR RAILWAY LOCATION

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Compiled by the

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ORGANIZATION.

The Construction Department will have charge of all surveys and construction of New Lines and Extensions, as well as Line and Grade Improvements of existing lines.

The Organization of Construction Department from Division Engineers will be as follows,—

Division Engineers with authority as assigned.

Asst. Engineers in charge of several sections of construction, location parties, or other important work, reporting to Division Engineers.

Resident Engineers in direct charge of a section of construction, reporting to Asst. Engineers.

The following rules are intended for the guidance of Engineers on location and construction, and are to be carefully and systematically followed. Suggestions for improvements or alterations are requested, these must in all cases be approved by the Chief Engineer before being used.

LOCATION.

GENERAL.

Before deciding upon the general location of any railway, the factors which go to make up its commercial effectiveness should be carefully considered. These are (1) Gross Earnings, (2) Operating Expenses, and (3) Fixed Charges. From an engineering standpoint, and as affected by location, they may be stated as (1) Traffic, (2) Cost of Transportation and Maintenance of Way, and (3) Cost of Construction.

Their relative importance, if amount of profitable traffic is dependent on location, may be considered in the order named. The most serious errors in location, occur in keeping away from present or probable traffic centres.

For heavy traffic, line should be located so as to reduce ton mile cost in transportation, while for light traffic, line should be located to reduce train mile cost.

Before any location or construction is decided upon, the commercial factors should be figured out. With a stated traffic, the Engineer must consider construction cost in connection with operating expenses (transportation and maintenance) before he can decide on the economical location of alternative lines in regard to gradients, distance, curvature, and rise and fall, the values of which are hereinafter given.

TRAFFIC AND TRANSPORTATION.

The cost of Transportation varies most directly with the number of trains required to transport a given volume of traffic, for which reason the train mile is taken as the operating unit. The commercial economy of operation is generally shown by the number of tons or passengers per train, and the ton mile and passenger mile are therefore taken as the commercial units.

Train Mile Cost may be divided into direct cost, which varies directly with train mileage; and indirect cost, which is constant under small changes in volume of traffic and varies only in a minor degree with large differences in volume. In comparing the commercial advantages of alternative lines, the Engineer will consider that excess traffic in both directions can be carried for the direct cost per train mile, and, if traffic is secured which will tend to balance trains, that it can be carried for one half direct train mile cost.

The direct train mile cost varies from 40% to 70% total cost, depending on volume of traffic, grades, locomotive power, etc.

With a given volume of traffic, train mileage will be multiplied by direct train mile cost to show the operating economy of different grades.

The value of characteristics of location, which affect cost of operation, is assumed to vary as the number of trains.

With a stated volume of traffic, a more economical location is obtained when interest and renewal charges on additional expenditures for construction are saved in decreased operating expenses, or when increased operating expenses are saved in reduced interest and renewal charges on cost of construction, the most economical location being obtained when these values balance one another.

After a line is once constructed, fixed charges are practically unaffected by variations in the volume of traffic. General Expenses for small increases, or decreases, are also unaffected. The expenses of conducting transportation, and a proportion of the Maintenance of Ways Expenses, vary more or less directly as the number of trains required to transport traffic.

Cost of Transportation.—The direct cost of handling a certain traffic may be considered to vary as the number of trains required to carry same, rather than the actual amount of traffic. The train mile may therefore be taken as the economic factor in operation.

Train Mile Cost.—Train Mile cost varies from 90c. to $1.20, and if no accurate data is at hand to compute same it may be assumed at $1.00. If the number of trains is decreased or increased in handling a certain amount of traffic, the amount so saved may be considered at 50c. per train mile, if trains hauled do not average over 800 tons; with heavier trains, 800-1200 tons, 55 cents per train mile; 1200 tons or over, 60c. per train mile.

Excess traffic may be considered to be handled for 60c. per train mile provided return loads are secured. If return loads cannot be had, cost will be considered at $1.00 per train mile.

If traffic is unbalanced, any traffic which can be secured to fill up empty trains may be figured at 30c. per train mile.

These latter values will be used in comparing alternative lines which touch fewer or more traffic centres.

Cost of Assistance to direct Operation.—The cost of 100% assistant engine, tractive power 20,000lbs., averaging over 80 miles per day will be assumed at 35c. per engine mile, both assisting and returning light; if engine assists both ways, with no light running, the cost per engine mile will be 40c.

If daily mileage is less than 80 miles, the following values will be used:—

40 miles per day, 50c. per engine mile, single crew.
50 miles per day, 45c. per engine mile, single crew.
60 miles per day, 40c. per engine mile, single crew, 45c. double.

70 miles per day, 35c. per engine mile, single crew, 40c. double.
80 miles per day, 35c. per engine mile, single crew, 37½c. double.
Over 80 miles per day, 35c. per engine mile, single or double crew.

These values are for 100% locomotives, if heavier locomotives are used, add 2% for increase of 10% in tractive power.

If road engines are at divisional point, and are used intermittently for assistance, the cost per engine mile will be 10% less If yard engine is used, 35c. per engine mile.

The Minimum Cost for Assistant engines when not at a divisional point or used for yard work, is $7,000. per year for single crew, or $9,000 per year for double crew. To this $1,000. per year will be added for Capital investment. The total number of engines required on a section when assistance is used is generally reduced, and a credit of $1,000.00 per year per engine saved must be allowed in the general scheme.

The cost of Doubling will be figured at 45c. per additional engine mile, plus $1.00 per train doubled.

The Cost of Switching is 27½c. per engine mile, and the Cost of Light Running is 25c per engine mile.

OPERATING VALUES for DISTANCE, CURVATURE, RISE and FALL, values capitalized at 5%.

DISTANCE.

Competitive traffic. Through rates. Traffic based on RATE PER MILE NOT INCLUDED.

Distances aggregating less than two miles in an engine run, not affecting track force, or train wages:

30 cents per train mile, = 2 cents per foot, per daily train per annum.

Cap. Value = 40 cents per foot, per daily train per annum.

Distances affecting train wages, but not requiring extra siding:

48 cents per train mile, = $175 per additional mile per daily train per annum.

Cap. Value = $3,500 per mile per daily train per annum.

Distances requiring extra side tracks:

62 cents per train mile, = $225 per additional mile per daily train per annum.

Cap. Value=$4,500 per mile per daily train per annum

Distances adding to engine districts:

$1.00 per train mile,=$365 per daily train per annum

Cap. Value=$7,300 per mile per daily train per annum

CURVATURE.—ALL TRAINS.

Main Line, Grades 0.6 and under. Cap. Value $6.00 per degree per daily train per annum.

Main Line, Grades over 0.6 and important branches. Cap. Value $5.00 per degree per daily train per annum.

Unimportant branch lines. Cap. Value $4.00 per degree per daily train per annum.

WHEN CURVES ARE ELIMINATED, THE CAP. VALUE PER CURVE IN EXCESS OF VALUE PER DEGREE IS

On main line and important branch lines, $50.00 per daily train per annum.

On unimportant branch lines, $25.00 per daily train per annum.

To this should be added all extra construction cost of rail braces, tie-plates, and guard rails.

Curves at the foot of velocity grades, at station sites, or causing check in speed are very objectionable, and must be treated separately.

RISE AND FALL.—ALL TRAINS.

Within freight-train velocity limits of 30 and 15 M.P.H. $2.00 per foot per daily train per annum.

Minor grades 0.5 and under (exceeding velocity limits) $12.00 per foot per daily train per annum.

Over 0.5 (exceeding velocity limits) $25.00 per foot per daily train per annum.

Ruling grades, $35.00 per foot per daily train per annum.

When ruling grade is 0.5 or under, figure minor grade to within .05 of ruling grade, after which assume grade as Ruling Grade.

When ruling grade is over 0.5, figure minor grade to within 0.1 of ruling grade.

LOCOMOTIVE TRACTION AND TRAIN RESISTANCE.

To find the maximum traction of any well designed locomotive, weight on drivers being known.

Maximum traction$=.\frac{1}{4}$ weight on drivers.

This result can only be obtained on very dry rail, when engine is working at slow speeds, and train resistance accordingly high. Engine must also be carefully throttled or wheels will slip, reducing co-efficient of friction between wheel and rail.

For *Ordinary Traction* over ruling grades, a speed of about ten miles per hour should be allowed. At this speed, the cylinder power is the limiting factor of the locomotive, and traction should be figured accordingly.

To find *Tractive Power at Drivers*, boiler pressure (P), diameter of cylinders in inches (d), stroke in inches (S), and diameter of drivers in inches (D) being known,

Tractive Power in pounds for Simple Engine=

$$\frac{.8\,Pd^2S}{D}$$

For Compound Locomotive d_h=diameter high pressure, d_1=diameter low pressure cylinder, and R=ratio of cylinder areas.

Tractive Power in Pounds for 2-Cylinder Compounds=

$$\frac{5}{6}\quad\frac{Pd_1{}^2S}{(R+1)D}$$

Tractive Power in Pounds for 4-Cylinder Compound=

$$\frac{5PS}{6D}\left\{\left(1-\frac{1}{R+1}dh^2\right)+\left(\frac{d_1{}^2}{R+1}\right)\right\}$$

In any well designed locomotive, the results obtained from above formulæ should be about 1/5 *weight on drivers*, and which may be taken as the tractive power at drivers if other data is not at hand.

To find the weight of train in tons that any locomotive can take up a given grade at ordinary slow speeds,

$$W=\frac{T}{20\,g+5\ (\text{or }9)}-w$$

W=being weight of train, w=weight of engine and tender, T=tractive force of locomotive, g=rate of grade.

Train resistance = 5 lbs. per ton loaded 2 contents to 1 of tare. If train is all tare, use 9 lbs. resistance instead of 5.

The increase in train resistance and decrease in tractive force of locomotive must be taken into consideration when speed is increased above eight to twelve miles per hour, as then the horse power of the locomotive is the limiting factor.

To find the Horse Power of a given locomotive, the separate items of *grate area*, *heating surface*, etc., would have to be known. A rough estimate of the tractive power at different speeds can however, be made from *boiler pressure*, *cylinders*, *drivers*, etc., from which H.P. can be figured. The mean effective cylinder pressure in per cent. of boiler pressure, per *Revolution* of *drivers* per minute being given, is as follows:—

MEAN EFFECTIVE CYLINDER PRESSURE (M.E.P.) IN PER CENT BOILER PRESSURE (simple engine).

Rev. per Minute.......	20	40	60	80	100	120	140	160	180
P.C. Boiler Pressure...	90	85	80	70	62	54	46	40	36

Rev. per Minute.......	200	220	240	260	280	300	320	340	360
P.C. Boiler Pressure...	32	29	26	24	23	22	20	19	18

For *Compound Engines* add 5% to these figures.

To change revolutions per minute (R.P.M.) to Miles per Hour (M.P.H.) diameter of drivers in inches being known,

$$\frac{\text{R.P.M.} \times \text{D}}{336} = \text{M.P.H.}$$

From this the M.E.P. at any speed can be found approximately, the *Tractive Power* at that speed will then be

$$\text{T} = \frac{\text{M.E.P.} \times d^2\text{S}}{\text{D}}$$

To find Horse Power at any given speed in miles per hour, multiply tractive power at that speed by the speed, and divide by 375,—

$$\text{H.P.} = \frac{\text{T} \times \text{S}}{375}$$

TRAIN RESISTANCE.

Train resistance varies with speed, length of train, weather conditions, wind, etc., and also if train has been standing or has been in motion for some time. The starting resistance may be considered at 15 lbs. per ton for long trains, and 20 lbs. for single cars. For speed of ten miles per hour and over, use the following formulæ, for ordinary train resistance in lbs. per ton. Trains loaded two contents to one tare, engines with tractive power about 30,000 lbs. or 1,000 H.P.

Grades 0.3 or 0.4. $$R = 4.0 + \frac{V^{5/3}}{100}$$

Grades 0.5 to 0.7. $$R = 4.0 + \frac{V^{5/3}}{80}$$

Grades 0.8 and over. $$R = 4.0 + \frac{V^{5/3}}{60}$$

If train is all tare, use 9.0 lbs. as constant. The H.P. required to move train at any given speed will be found by the formula,

$$H.P. = \frac{R \times S}{375}$$

in which R=train resistance at given speed; S=speed in miles per hour.

GRADES.

The essential feature in a location for freight traffic is the ruling grade. Passenger trains are limited by speed requirements rather than tractive effort of the locomotive. This is also true for freight trains on long sections of continuous rise, the H.P. of the locomotive being the limiting factor.

Where low ruling grades of from 0.3 to 0.5 are being worked to and can only be obtained by long sections, about ten miles in length of continuous rise, and supporting ground for same is not obtainable except by very long cuts and fills, it would be economical to insert steeper grades, not to exceed ruling grade more than 0.1, provided adverse grades are not inserted and engine can be worked to full capacity over slack grades.

When any grade limits the weight of the train over any section, it is termed the ruling or limiting grade. Steep grades which can be operated with assistance or doubling, need not be the ruling grade.

On new lines where certain main divides must be crossed, the immediate approach to which is steep, compared to the general country through which line passes, it is advisable to adopt as low a ruling grade as possible, surmounting the immediate summit by using a continuous heavy grade, as by this, distance can be saved, and work reduced. The rating on this grade should be from 50 to 60% that of ruling grade, and trains on it will be operated with assistance.

When pusher grades are necessary, it is advisable to have them adjacent to divisional points, and divisional points and pusher grades should be so located when possible. Pusher grades should be located out of, rather than into, divisional points.

Ruling grades should be arranged to economically handle probable traffic; over adjacent main line sections they should be similar, and at junction points, to suit increased or decreased traffic. A greater percentage of same ruling grade on different sections will also cause reduction in train rating.

Train stops on ruling grades should be compensated according to proportion of ruling grade to length of section, varying from zero to 10 feet.

If ruling grade one way is 70% of section, compensate stops = 0.

If ruling grade one way is 40% of section, compensate stops = 5.'

If ruling grade one way is 10% of section, compensate stops = 10.'

At intersections on grades, in which the difference in rate exceeds 0.4, vertical curves will be used, which will have the following change in rate per 100':—

Main Line, grades under 0.6, vertical curves 0.05 in sags, 0.1 on summits.

Main Line, grades 0.6 to 1.2 and Branch Lines, 0.1 in sags, 0.2 on summits.

Unimportant Branch Lines, 0.2 in sags, 0.4 on summits.

Ruling grades on curves will be compensated .04 per degree of curve. Light grades should be made continuous on curves and tangents.

COMPENSATION OF GRADES IN TUNNELS.

Compensation of grades in tunnels is one which is usually eliminated by conditions. Tunnels usually occur near summits and only require grades for drainage. Under special conditions, if length is not much increased, a good rule is to make grade half maximum grade. If a maximum grade is required, the following reductions are figured to allow for bad rail, and decreased tractive power of steam locomotive:—

Length of Tunnel.	Ruling Grade 0.5 Tunnel Grade.	Ruling Grade 1.0 Tunnel Grade.	Ruling Grade 2.0 Tunnel Grade.
200	0.5	1.0	2.0
500	0.45	0.9	1.9
1000	0.4	0.85	1.75
2000	0.33	0.75	1.55
5000	0.25	0.60	1.25

Compensation for curves, Tunnel under 500′ .04 per degree.
" " Tunnel 500′ to 1000′ .05 per degree.
" — " Tunnel over 1000′ .06 per degree.

GRADE REDUCTIONS.

When grades on operated lines are to be reduced, the new ruling grades on adjacent sections or sub-divisions should be so arranged that the least delay to through traffic will be necessitated, and assistance to direct operation reduced to a minimum. Steeper grades over one section may be nullified by using heavier locomotives.

The economic value of different grades will be determined by the number of trains required to handle a certain traffic. On operated line the actual traffic will be taken for as long a period as possible; and with this as a basis, the yearly number of trains required multiplied by the length of the section will give the train mileage. This multiplied by the direct cost per train mile, will give the yearly cost of operating. The saving resulting from the adopting of flatter grades and reducing train mileage may thus be determined.

Trains will be figured lighter than the rating over ruling grade according to its rate, and total length as compared with section, the reduction will generally be as follows,—

Grades 0.3,	25%
0.4,	20%
0.5,	18%
0.6,	16%
0.7,	14%
0.8,	12%
1.0,	10%

The values for assistant engines, doubling, etc., is as per "volume of traffic."

The value and cost of grade reductions will be shown on standard forms X. 11, 35-36-37-38.

VELOCITY GRADES.

In all work, when it is possible to save a considerable amount in cost of construction, velocity grades will be used as per standard sheets. These sheets are figured so that the energy stored up in a moving train may be utilized in surmounting grades steeper than the ruling grade for which train is loaded.

The velocity heads and speed grades are shown for speeds 5–40 M.P.H.

The velocity head does not represent the height in excess of ruling grade which train could overcome, owing to the fact that the tractive power of the locomotive is much less at high speed than at low speed; this decreases length of steeper grade which train can surmount.

To use sheets, select the one corresponding to the grade which has been adopted as ruling grade and for which the train has been loaded at 10 M.P.H. The speed acquired or lost will be found by following along the curved line corresponding to the grade on which the train will run, the starting point being at the intersection of the horizontal line corresponding to speed, the final speed being shown by the intersection of grades, and vertical line corresponding to the distance passed through.

The maximum allowable speed for freight trains is 30 M.P.H. and minimum 10 M.P.H.

After ascending a steeper grade by use of velocity, if ruling grade will follow, assume the limit of speed at 11 M.P.H., if grade is 0.1 less than ruling grade 10 M.P.H., and if 0.2 less, 9 M.P.H., which is the minimum speed to be figured to in any case.

Velocity grades should only be used where considerable saving will be effected by their introduction, and where no incidents will occur in operation which will reduce speed below that assumed, curves at the foot of velocity grades must be avoided or speed reduced to safe limits.

Velocity grades steeper than twice the ruling grade rate + 0.2 should not be used except in special cases.

RECONNAISSANCE.

The field force of a reconnaissance party will vary according to settlement of country through which surveys are being made. For unsettled country it will consist of Engineer in charge, and assistant, with or without subordinates, cook, packer or teamster, and horses.

The first step is to obtain the best available maps of the country, these should be studied by the Engineer, so that the general idea of the watersheds may be clearly fixed in his mind.

The reconnaissance must not be of any line, but of an area, and a thorough knowledge obtained of the controlling features of the country, included in as large an area each side of the air line between the two terminii as there is any possibility of the line passing through. Prepossessions in favor of the most obvious route should be set aside, especially when such route runs near highways or open districts.

Lines hard to traverse on foot seem worse than they really are, especially if country is covered with a small and close growth of timber. Ruggedness of detail, rock points, etc., extending over short distances, seem much more difficult of economic location than long rolling slopes which will necessitate more expensive construction. Routes will be compared upon the value of total cost, both in constructing and operating. Short sections of expensive work, when averaged with the balance of a line, may show less cost per mile than a line of more uniform character.

When checks cannot be made on known elevations, and reliance is to be placed on barometer reading, two or more barometers should be used, one barometer being stationary, observations of which should be made every half hour, and a daily curve plotted or calculated showing difference between readings and true elevations, the readings of the exploration barometers may then be reduced.

If it is impracticable to have a regular stationary barometer, the changes morning, noon and night, when barometer is stationary will be noted, from which the variation at any time during the day may be approximately figured, and elevations reduced. This will also be done as a check on stationary barometer.

The form of notes will be as per standard (see note book forms).

The Engineer will also keep a diary, which should preferably be entered into note book. This should include all items of interest pertaining to the work.

A complete sketch map of the country, showing the principal water courses and divides, should be made as the reconnaissance proceeds; this should show where each stream crossed joins another, until both have passed beyond the possible limit of the area under consideration.

After the first reconnaissance, the Engineer can usually decide that one or two lines are preferable to the others within the area surveyed. Over this line, or lines, he should make a second reconnaissance, so as to obtain more detailed information respecting grade, alignment, cost, etc., and to obtain check on first elevations.

The Engineer should note determining features of the line, and reasons for avoiding prominent objects, and sections of location, noting particularly the physical difference between the two sides of the same valley, and their effect on construction and operation.

Lines should be explored from the main divides, working down to the lower elevations.

The really vital and dangerous errors in location, such as erroneous selection of general route or gradients, passing by local towns or probable centres of traffic, are always committed in the reconnaissance or exploration survey.

The reconnaissance report must always be accompanied by map and profile (see Maps, etc.).

PRELIMINARY SURVEY.

The full preliminary or location party will consist of locating engineer, transitman, head and rear chain, leveller and rodman; draughtsman with or without assistant, topographer with one or two assistants, cook and cookee, teamster, packers.

When surveys run near wagon roads or in the prairie, it is preferable to drive to and from work.

Engineers are in immediate charge of parties, and are expected to see that all instruments, tents, stationery, provisions, etc., which they require for the proper and vigorous prosecution of their work are supplied, and outfit kept in repair (see lists).

Before the preliminary survey is commenced, the Chief Engineer will determine, from the exploration surveys, the ruling grade and maximum curves to be used. He will also determine the probable volume of traffic, indicating the number of daily trains for which line is to be located, as well as purpose of line, and standards of construction. The route of best grade and alignments should be first projected, afterwards side lines which avoid heavy work by broken alignment but do not decrease train rating, and finally the introduction of temporary steep grades and broken alignment, as well as permanent grades which under increased traffic will be operated with assistance.

All surveys should, however, be made with regard to future permanent construction, and temporary work introduced should be cut down to the least amount possible. Preliminary lines should be run with speed, and to approximate closely to the located line, all unnecessary clearing should be avoided at the expense of introducing more angles The object of the preliminary is to form a base for the topography, so that the location may be correctly projected

When following down a suspended grade, the Engineer will note the probable curvature of the located line, and compensate his preliminary grade to suit; the compensation is generally 0.05 and runs in mountainous country to 0.2.

In very rough, steep side hill, especially in ravines where a line must be carefully fitted, two or more preliminary lines should be run, and tied together, this will serve as a frame work for the topography, and different locations may be accurately projected. The practice of running lines near each other and plotting on separate plans must be avoided.

At critical points where the maximum curve will be inserted, the deflection on the preliminary should be figured to suit, and short chords used.

Compass lines will be used only when considerable time and clearing can be saved. This is not the case if the level limits speed of party. Compass readings must always be taken as a check in transit work.

All courses of the line, both true and magnetic, must be taken, the former only being noted on plans.

To obtain true north, an observation of the north star should be taken when starting survey, and additional observations for correcting meridinal divergency when the survey shall attain a departure of one-half degree of longitude.

To illuminate cross wires at night, wrap a piece of tracing linen around the object end of telescope, so that one-half of object glass is loosely covered. This linen may be secured by rubber band, then illuminate by lantern from one side.

A good night foresight may be had by marking an X on tracing linen tacked over box with a candle or lantern behind it. On small surveys the true north may be assumed by deflecting from magnetic readings.

Plot all lines by latitudes and departures.

By reversing telescope on alternate angles cumulative errors may be nullified.

Designate preliminary lines by the first letters of the alphabet, A, B, C, etc., and variations to these as A^1, A^2, B^1, B^2, etc.

LOCATION.

The location will be projected from the "preliminary," the direction of tangents being obtained by scaling and figuring the natural tangents from the base lines of the latitudes and departures, the intersection angles of curves being thus obtained, protractors will only be used for checking

In running the first location only correct the more serious errors by backing up. Minor improvements should be noted but not re-run, as the first location advances. After completing the first line, if instructed by the Chief Engineer, the second location should be run. In any case the topography or plans must be full enough to enable improvement in location to be projected, and estimates made. Location stakes shall be marked L, and changes in same L^1, L^2, etc. The second location shall be designated by 2L, and changes or deviations in same as $2L^1$, $2L^2$, etc.

The location of stations, water tanks, coaling plants, crossings, etc., should be very carefully considered, and grades adjusted for same, so as to reduce the disadvantage of train stops to a minimum. Train stop at the foot of grades should always be avoided if possible, both on account of stopping and starting, when unavoidable, either by change in location or stopping point, the grade should be reduced, so that heaviest trains can start without inconvenience.

Broken alignment should also be avoided at the foot of grades, especially if same is to be run by velocity or speed reduced to safe limits; in no case shall velocity grades be figured for speeds exceeding 30 M.P.H.

A grade of 0.2 is required for drainage cuts.

The Locating Engineer will note the material along line, observing quarries, timber, etc., adjacent to line, with a view to their use in construction, also water powers, traces of mineral deposits, etc.

Stream diversions usually prove cheaper, both in first cost and maintenance, than bridging, especially when excavated material can be used for filling.

Trestling, unless required for waterways, or temporary line, should not be used unless cost of embankment exceeds first cost of trestle and subsequent cost of filling

Engineers will pay special attention to the length of bridges required, and size of culverts. The same should allow for a margin of safety, but should not be unnecessarily large. The area drained should be noted, and cross-sections of streams taken at flood height. The material of bed of stream and probable foundation for structure should also be noted.

Detail profiles on a natural scale of 20′ to the inch should be made of all important crossings; this should show centre line for at least 100 feet beyond each end of the proposed bridge, also parallel lines at 25′ each side of centre line; these should be shown by dotted lines, the up-stream line being even dotted, and down-stream dot dash. Highwater mark, surface indication of rock soundings, etc., should also be shown, as well as stations, grade line, and rate of grade.

Engineers must beware of being misled by so-called rainless districts. Timber structures for waterways may be judiciously used, but should always be made of sufficient size, so that permanent structures may afterwards be economically built.

Suitable and well situated sources of water supply should be carefully noted. Sealed samples of water should be sent to the Chief Engineer for analysis when suitability of water for locomotives is doubtful. If possible avoid grade crossings, especially with foreign lines. $40,000 may be considered justifiable expenditure to eliminate single track crossings.

When beginning and end of line forms a junction point with any constructed line of railway, full notes of connection must be made, and lines run along constructed railways, so that same may be accurately located on plan and levels taken for profile; the junction point should also be tied in to nearest head-block, or some fixed point.

ALIGNMENT.

Broken alignment, unlike heavy grades is not a constitutional defect in operating especially if curves are properly spiralled. Curvature, however, is often introduced where with a slight increase in construction cost, it might be greatly decreased or cut out entirely.

The use of sharp curvature at one place does not justify its use at other points in the same section.

Curves on the first location will not be spiralled unless same is to be used as a final location. The beginning and end of curves will be marked "B.C." and "E.C." When spiralled the designation will be "BS," "BC," "EC," and "ES." Compensate ruling grades on curves 0.04 per station per degree of curve, the compensation to begin at the nearest full station to beginning or end of curve, or if spiralled, to middle point of spiral. If line is very crooked, extend compensation along tangents to avoid sharp changes in grade.

Spirals must be used on all final location. Under ordinary conditions the length in feet of spiral for main lines will be equal to the degree of curve multiplied by 100 feet, the maximum length being 400 feet. On branch lines or rough country spirals may be shortened, the length being equal to the degree of curve multiplied by fifty feet, the maximum length being 200 feet. The minimum length of tangents on main lines between curves in opposite directions will be at least equal to half the length of the two spirals required for curves, the minimum in any case being 200 feet. For curves in the same direction the minimum length should not be less than 800 ft. or 400 ft. between spirals.

No curves will be shorter than 300 feet or flatter than 1° unless specially allowed. Do not use very flat curves with large central angle, curves should not generally be shorter than 500 feet, not longer than 1500 feet, unless maximum curve is used, as over this length it is better to shorten curves and lengthen tangents.

On the same section of line if sharp curves and short spirals are necessary to avoid heavy construction, do not use this standard over whole section, but try to improve other portions so that fast speed may be made to compensate for slow speed over first mentioned portion.

On compound curves when difference in curves exceeds 2°, spirals will be used connecting curves. The length in feet of spiral will be difference in degree of curve multiplied by 50, the maximum length being 200 feet. Spirals will be run as per tables and instructions furnished.

Connect with all township and sub-division lines, county or parish boundaries, as well as noting chainage of all fence lines crossed. These measurements should include the station on and the angle made by the location line with each township, section, or other land line, and the distance along the land line to the nearest section or quarter corner or other fixed point.

Care should be taken that three sides of a triangular measurement are not shown in plan together with one or more angles, unless these measurements check.

When line runs through villages or towns, take all measurements so that line may be tied to the fixed points in the town layout. Secure tracings of town plats as contained in the district registry office, with dates and certificates, and send copies to the Division Engineer's office. On preliminary surveys, secure only enough land ties so that line can be spotted on map of country, but on final lines all the land connections must be complete, for filing purposes.

TRANSIT WORK.

In order to secure accurate alignment on long tangents, take double sights by reversing telescope and splitting differences, in running in curves reverse telescope on alternate set-ups to correct errors in adjustment.

Do not run curves to intersection points unless unavoidable or making junction with other lines. If curves are run to intersection, back in curve so that the central angle can more readily be changed from end of curve, and so not interfere with adjustment of location. Spirals should not be run in on first location, unless directed.

In running in curves do not exceed a tangent angle of fifteen degrees unless necessitated by finishing out a curve or inability to secure set-up.

The transitman will assist draughtsman to figure out courses, at the end of each day's work.

LEVELS.

Levels in preliminary need not be taken with great accuracy at stations, especially when level limits speed of party, but at all turning points and bench marks strict accuracy is to be observed.

All levels should be reduced to sea datum if possible, or to same datum as levels at starting point, if same is from some recognized elevation. The difference between datum and sea level should always be noted.

Bench marks on preliminary, where time is limited, need not be closer than one mile, but good turning points must be made and location of same recorded by rodman. These records will be placed in level book at the close of each day's work.

The leveller should use hand level to work down in narrow hollows and over heights which can be turned by instrument.

Always keep level notes figured out as taken, so that any elevation of any point may be had when wanted by locating engineer. Try to keep backsights and foresights as even as possible. Bench marks on location should be put in at 1000 or 2000 ft. intervals, depending on nature of country, etc., and should be placed at or near the even ten stations, so that they can be found without notes or profile. Bench marks should always be shown on profile.

TOPOGRAPHY.

On preliminary wherever helpful to location, and on location where helpful to revision, topography must be carefully taken.

The limit of topography required will depend on nature of country over which line is run, 700′ each side of line being maximum. In nearly level but broken country it is preferable to run two or more lines than to extend the topography over too wide a belt.

Topography should be carefully taken, showing 5′ or 10′ contours, depending on nature of country and survey. Every fifth contour at 25 or 50′ elevation should be shown by heavy line.

On supported grade lines, the contour of the grade should be shown by dotted line.

Topography is not intended as a safe-guard against the larger errors of location, but for correct projection of detail. The final work in location must always be done on the ground.

NOTE BOOKS.

The note-books used will be memorandum books, transit, level, topography, and office books. Memorandum books should be ruled in squares, so that sketches can be made to scale if required. Field books must indicate each day's work giving date, and time of starting and finishing work. All notes must be indexed, the pages being numbered in pencil or India Ink and adopted or abandoned lines marked as such. All notes must be made clear, plain, and self-explanatory. Preliminary Survey notes must be made with care. All notes must be compiled in evening, the alignment notes given to draughtsman, courses figured, and profiles plotted.

On all surveys, especially those of small scope, all information should be placed in as few books as possible.

Original notes should be preserved, as they are the only ones admissable in a court of law. Note-books should be marked on outside of cover, and inside on first page, and all notes will be kept as per standard forms.

MAPS, PLANS AND PROFILES.

GENERAL.

All maps, plans and profiles are to be drawn with the top of the paper to northward or westward, the general direction between termini being considered. Lettering and figures should be made to read looking from the bottom, or the right hand of the paper, excepting the chainage, which on plans should be marked at right angles to the line, and read in a continuous ascending direction as it runs. Names and designations should be written parallel with the top and bottom of the paper, or with the lines of the object which they denote, as for instance, Province, County, or Township names should be parallel with the paper; the names of lot owners should be parallel with, or at right angles to, the lot lines; station names should be parallel with the centre line of railway, and so forth. All lettering should be plain, neat and devoid of ornamentation, and should indicate by its size, style and strength, the relative importance of the object designated. Specimen location plan and profile will be furnished, which should be followed closely. All plans must be dated and bear the signature of the Engineer in charge, and the draughtsman's initials; the date of any subsequent alterations or additions should also be noted and initialled. The scale or scales to which the plan is drawn must be shown under the title. The title should, if possible, be put on the right hand end of the plan, leaving ample room for notes, and should be plain and specific as to its nature and extent, stating the chainage and mileage of beginning and ending, the zero of both being noted. On the outside at each end of the plan or profile, sub-titles should be put giving similar information in a concise form. All plans should have a compass point indicating both true and magnetic north.

The names of all streams and rivers should be given and the direction of flow indicated by arrows. The names or destinations of all roads should be shown on plans, and any portions of existing railway lines should be marked at either end from or to its sectional or divisional points. Plans of track or work as existing shall be shown in full black, and work to be abandoned in dotted black lines. Proposed new work will be in full red lines (vermilion) and may be lightly tinted (carmine). Dotted red lines will indicate indefinite propositions or possible future extensions. As colouring is detrimental to blueprinting it should be used on tracing linen only where really needful, and then merely the lightest and most transparent tints. In using tracing linen, all drawing must be on the dull side, and colouring where necessary, on the smooth.

All plans smaller than 1200 feet to the inch shall be termed Maps.

RECONNAISSANCE MAPS.—The maps accompanying a report should be drawn to a scale of from ½ to 4 miles to the inch, depending on the nature of the survey, the prevailing scale being 1 inch to the mile. They will show the larger land sub-divisions, towns, villages, and probable centres of traffic, the general geographic and topographic features of the district, the watersheds and all low divides. The topography shall be shown by contours 25′ or 50′, sketched in as nearly as can be determined, noting accurately elevations at controlling points. Beyond the limits of actual exploration presumable contours may be indicated in dotted lines. Existing railway lines should be prominently shown in black. A profile drawn to one of the following scales shall accompany the map: —

1. Horizontal,	1 mile to	1 inch.	Vertical,	100 ft. to 1″.
2. "	4 "	1 "	"	200 " 1″
3. "	10 "	1 "	"	200-100′ to 1′.

Numbers 1 and 3 should be made on ordinary transparent cross-section paper 10 x 10, and No. 2, which is the general scale, on transparent profile paper, plate "A." On short survey the profile should be traced on same plat as the map. Ruling grades will be shown in firm full lines and broken grades dotted. Controlling elevations should be marked, and also the principal places passed through, and structures of any considerable magnitude that may be required.

PRELIMINARY PLANS.—These plans will be drawn generally to a scale of 200 feet to an inch, although in comparatively easy country, 400 feet scale may be used, and in mountainous and very rough country 100 ft. is desirable. The crossing points of Latitude and Departure lines forming angles of squares not exceeding 10 inches each side, should be shown as a base from which directions of tangents on projected locations may be obtained and intersection angles measured. Contours every 5 or 10 feet as may be directed, will be drawn in sepia or brown ink in fine lines with every fifth one heavy, the lines being interrupted at suitable intervals to mark the elevation figures. Grade contour line should be shown in dotted blue. All contiguous buildings, structures, quarries, and probable water powers, etc., that may be affected by he line or any revision of same must be shown and their nature noted. The preliminary line run should be shown in a firm emerald green line, the stationing of all hubs being given and each 100 ft. station ticked off and every fifth or tenth numbered. The projected location should be shown on plan in dotted red. The astronomical bearings must be marked, and all water courses, and sufficient land lines shown for obtaining roughly the position of the line. Where several disjointed preliminary lines are run they should be distinguished by the first letters of the alphabet, A, B, C, D, etc., and variations to these A^1, A^2, B^1, etc., marked in plain bold lettering at junction and other appropriate points. Wherever possible these separate lines should be plotted in whole or in part on the same paper. The original plat should be made on Manilla paper, 36″ wide, and a copy for the Division Engineer in 10-mile lengths made on linen, 30″ wide preferred, but up to a maximum of 36″ may be used if necessary, and with only such breaks as are quite unavoidable. The point of breaking should be judiciously selected as near a long tangent as possible, and about 6 inches of the line itself should be repeated on the continuation. The Preliminary Profile will be on standard scale, horizontal 400 feet and vertical 20 feet to an inch, and plotted on transparent profile paper 11″ wide in lengths corresponding to accompanying plan. When comparative profiles are plotted over each other, the several ground lines should be distinguished by being shown full, or in short dots, long dots, or long and short dots, and the grade lines similarly in red.

LOCATION PLANS.—These will be plotted on a scale of 400 feet to the inch, but in prairie sections 1000 feet may be used. They will be made similar to preliminary plans as regards framework of latitude and departure, and will show such contours as are necessary for revision of line. The crossings of all provincial, county, district, municipal, township, and range boundaries, must be shown, also all lots and sub-divisions, existing fences and roads, with the chainage and angles of crossing. All contiguous buildings, etc., will be as shown as on preliminary. The names of property owners must be ascertained and shown, and in final location plans, the length, width and area of land required from each given, especially in places where extra land may be needed to accommodate slopes.

The located line will be shown in a firm bold red (vermilion) line, and in final location the limits of right of way in fine red lines. Radial lines, if shown, should be fine dotted red, and curve centres marked with a small V The astronomical direction of all tangents must be shown, and the degree, central angle, spiral angle, and stationing of B.S., B.C., E.C., and E.S., of each curve marked. It is of the utmost importance that the connecting point of any located line with an existing line should be definitely established in relation to some easily recognized point on the existing line of such permanent nature as a station building, or face of bridge abutment.

Location plans will be made of a preferred width of 30″, maximum 36″ and in length approximately 20 miles, but, for convenience in preparing registration plans should conform to limits of the county or registration districts, that is to say a plan need not be cut exactly in 20 mile sections, when a few miles more will carry it to the end of the registration district. Location plans and profiles should be made after the manner of the Standard Specimen Plan and Profile which will be furnished. The profiles shall be plotted on transparent profile paper, 11″ wide, and in lengths corresponding to its accompanying plan, and always to horizontal scale of 400 feet, and vertical 20 feet to an inch. They will show the grades, curves and alignment, mileage, highway and railway crossings, open drains and water courses, timber growths, stations and structures proposed. At Stream Crossings wherever structures are proposed the elevation of high and low water should be marked and the nature of material for foundations noted.

Railway, Highway and Navigable River Crossings.—Special plans and profiles should be made of all railway crossings, also highway crossings, where structures are required, and all navigable waters, and stream crossings of considerable magnitude. The plans and profiles of railway and highway crossings should be made on a scale of 100 feet to an inch, and should give all necessary elevations and details, including a profile of the line to be crossed. The plans of navigable rivers and important stream crossings should be on a scale or 50 of 100 feet and and should show land contours every 5 or 10 feet. The profiles should be on a 10, 20, or 40 foot natural scale. Parallel lines at intervals of 25 feet on each side of centre line should be run, or cross-sections taken for soundings.

The alignment, grades, stationing, elevations of high and low waters, direction and rate of current, should be shown and all information as to the nature of ground for foundations. Should there be any existing railway or highway bridges over these rivers in the vicinity of proposed crossing, profiles of the[m] should be furnished showing waterway and headway clearance[s].

Progress Profiles.—These will be made on ordinar[y] tracing cloth, as per standard, the colouring being done on th[e] face with as bright tints as possible, the colours noted underneat[h] being used. All grade or other figures or lettering should b[e] kept clear of the cuts and fills. The classification of materi[al] and quantities should be noted immediately, over each cuttin[g] by the initial lettering, C.E. standing for common excavatio[n] H.E. for hard excavation, S.R. for solid rock, and L.R. for loo[se] rock. Where embankments or any considerable portions of sam[e] are made with rock, the letters R.F. for rock fill should be note[d] underneath. At least $1\frac{1}{8}$ inches should be left clear between th[e] datum line and the bottom of the linen, providing room for a seri[es] of three double parallel lines $\frac{1}{10}$ of an inch between each lin[e] and $\frac{1}{8}$ inch between each set, and $\frac{1}{4}$ from the uppermost line t[o] the datum line. On the spaces afforded by these double line[s] the daily progress will be marked, and the monthly progre[ss] coloured, of the Tracklaying, Ballast and Surfacing, in the ord[er] named, commencing from the top. Also at the top of the profi[le] underneath the notation of Timber Growth a double line of [$\frac{1}{10}$] of an inch spacing will be drawn for indicating the progress [of] Clearing. The standard monthly colouring for progress profil[es] will be as follows:—

January.... Sepia.	July......... Indian Ink.
February... Indian Red	August...... Chrome Yellow
March...... Neutral Tint.	September... Cobalt Blue.
April....... Burnt Sienna.	October. .... Vermilion.
May........ Emerald Green.	November... Violet Carmine.
June........ Carmine.	December.... Hookers Green No.

REGISTRATION PLANS.

Maps, Plans and Profiles to be examined, sanctioned a[nd] deposited with the Board of Railway Commissioners for Cana[da] and the Local Registration.

General.—These plans will comply with the requir[e]ments of the "Railway Act." They will be made on tra[c]ing cloth of a maximum width of 36″, preferred width 30[″]. Ample space should be left under or alongside of the title [to] afford room for signatures, memorials, etc., necessary. This space should be at the bottom of the linen, so that the Registrar's seals may be easily affixed.

MAP OF GENERAL LOCATION—AS PER SECTION 157—This should be made on tracing cloth to a scale of not less than 6 miles to inch and will show in black the termini and the principal towns and places through which the line is to pass, the railways, navigable streams, tide water, and physical features of the district, within a radius of thirty miles. The line proposed to be constructed will be shown boldly in red. From a vandyke taken of this tracing, three vandyke prints on linen should be made, signed and deposited by the Secretary.

LOCATED LINE, PLAN AND PROFILE, SECT. 158.—Should be similar to Standard Specimen Plan and Profile, as already described, with the exception that no contour nor latitude and departure lines need be shown, and also invariably, that the limits and areas of all lands proposed to be acquired be shown in red. The centre line should be a firm bold vermilion line and the limits of right of way in finer red lines. Radial lines need not be shown, the points of curvature being merely ticked off on the line. The length of the plan shall be governed by the extent of the County or Registration District which it traverses, but should not greatly exceed the prescribed length in one section of 20 miles on a 400 ft. scale. Profiles should be on tracing cloth and in conformity with the accompanying plans. For short branches if there is room, they may be shown on the same plat, as may also the Book of Reference to accompany the plan, which should otherwise be made on the Company's printed form.

PLANS TO ALTER LOCATION OF LINE, PREVIOUSLY SANCTIONED OR COMPLETED, SECT. 167.—These plans and profiles should be similar to above, excepting that the original location grades, curves, etc., must be shown (in black) as well as the changes desired or necessitated (in red).

PLANS OF COMPLETED RAILWAY. SECT. 164.—These plans and profiles should be made similar to the Located Line plans and profiles already described, excepting that the centre line of Railway should be shown in blue and the limits of right of way in fine black lines. The blue used should be opaque for

blueprinting, and at the same time as bright as possible, a mixtur
of Prussian Blue and Chinese White will do, but Cobalt Frenc
Blue and Chinese White is best. The limits and areas of land ac
quired should be accurately shown and computed, and all lan
ties shown complete. Original fence lines should be finely dotte
across the company's right of way.

BRANCH LINES NOT EXCEEDING 6 MILES. SECT. 221-225.-
Plans, profiles and books of reference similar to those for locate
lines should be made, but these should be deposited by th
Secretary first in the local Registry office, and four weeks publi
notice given, before application is made and plans deposite
with Railway Board.

RAILWAY CROSSINGS OR JUNCTIONS. SECT. 227.—Three se
of plans for these showing both roads at point of crossing mus
be made on a 100 ft. scale, and also three sets of plan, an
profile, made on a 400 ft. scale showing bothroads on eithe
side of the proposed crossing for a distance of 2 miles

HIGHWAY CROSSINGS. SECT. 235 TO 243.—Plans of crossin
to be on a 400 ft. scale and profiles 400 ft. horizontal and 20 ft
vertical, and must show at least half a mile of railway and 30
feet of highway on each side of crossing. Also profile of High
way for 300 ft. on each side on a sc le of 100 ft. horizontal an
20 ft. vertical.

CROSSINGS OF NAVIGABLE WATERS, BEACHES, ETC., SECT. 18
—Two sets of plans, profiles, drawings, and specifications, mad
on convenient scale, and, if possible, on one drawing.

ESTIMATES.

Estimates must be kept up with location and quantitie
recorded on the profiles for each cut or fill, and tabulated fo
each mile section. They will show the quantities of clearing
grubbing, grading, minor structures, foundations and all suc
information as the Assistant Engineer may be conversant with

The estimates for bridges and all items above sub-grad
will be made by Division Engineer. Grading will be divide
under the headings of "solid rock," "loose rock," and "commo
excavation." If cemented gravel or hardpan exists in suc
quantities as to make it of importance, it should be reporte
on and classified as "hard excavation."

The quantities of excavation will be figured from level cutting tables or quantity scales. When the side slopes become an important factor, the proper additions should be made as per the following tables:—

TABLE OF % INCREASE DUE TO SLOPE OF NATURAL SURFACE.

20 FT. ROADBED. SLOPE ONE TO ONE.

Slope of Ground.	Centre Cut in Feet.								Slope of Ground.
	5	10	15	20	25	30	40	50	
5°	2	1	1	1	1	1	..	..	5°
10°	6	4	4	4	3	3	..	..	10°
15°	14	10	9	9	8	8	..	..	15°
20°	27	20	18	17	17	16	..	..	20°
25°	50	37	33	31	30	30	..	..	25°
30°	90	60	54	51	49	48	..	..	30°

TABLE OF % INCREASE DUE TO TRANSVERSE SLOPE OF NATURAL SURFACE.

16 FT. ROADBED SLOPE 1½ TO 1.

Slope of Ground.	Centre Fill in Feet.								Slope of Ground.
	5	10	15	20	25	30	40	50	
5°	2	2	2	2	2	2	..	..	5°
10°	11	8	8	8	8	8	..	..	10°
15°	29	22	21	20	20	20	..	..	15°
20°	58	48	46	45	44	44	..	..	20°
25°	135	106	103	100	99	98	..	..	25°
30°	407	341	322	314	310	307	..	..	30°

When instructed by Division Engineer, estimates including everything necessary to complete the line ready for operation will be made out on standard forms, the prices for grading, bridging etc., being furnished.

Care should be taken that sufficient right of way be taken to cover slopes and land required for station ground and terminal purposes.

Estimates should be made in as much detail as possible, and should be full and complete so as to include everything required to complete the road ready for operation.

SUPPLIES AND EQUIPMENT FOR FIELD PARTIES

SUPPLIES FOR 14 MEN, 30 DAYS.

Allspice, ground....	½ lb.
Apples, evaporated..	50 lbs.
Apricots, evaporated	25 lbs.
Bacon............	100 lbs.
Baking Powder.....	10 lbs.
Baking Soda.......	3 lbs.
Barley............	10 lbs.
Beans............	50 lbs.
Beef, dried.........	25 lbs.
Butter............	60 lbs.
Candles...........	1 box.
Cheese............	25 lbs.
Cherries, canned....	1 case.
Cinnamon, ground..	½ lb.
Coal Oil...........	1 case.
Codfish...........	25 lbs.
Coffee............	40 lbs.
Corn (canned)......	2 cases.
Cornmeal..........	30 lbs.
Corn starch........	10 lbs.
Corned beef........	1 case.
Cream, evaporated..	2 cases.
Currants...........	10 lbs.
Flour.............	400 lbs.
Flour, Buckwheat...	50 lbs.
Ginger, ground.....	½ lb.
Ham.............	100 lbs.
Lard..............	40 lbs.
Lemon extract......	1 bottle.
Lye..............	2 lbs.

Milk, Condensed....	1 case.
Macaroni...........	1 box.
Matches...........	12 boxes.
Mustard...........	2 lbs.
Nutmegs...........	¼ lb.
Oatmeal...........	40 lbs.
Onions............	20 lbs.
Peaches, canned....	2 cases.
Peaches, dried......	50 lbs.
Pears, canned......	1 case.
Peas, canned.......	1 case.
Peas, split.........	20 lbs.
Pepper, ground.....	1 lb.
Potatoes..........	400 lbs.
Pickles...........	6 bottles
Prunes, dried.......	50 lbs.
Rice..............	25 lbs.
Raisins...........	1 box.
Sago.............	10 lbs.
Sal Soda..........	10 lbs.
Salt..............	20 lbs.
Soap.............	1 box.
Soda Crackers......	1 box.
Sugar.............	150 lbs.
Syrup.............	5 gals.
Tapioca...........	10 lbs.
Tomatoes..........	2 cases.
Tea, Black.........	15 lbs.
Tomato Catsup.....	6 bottles

Vanilla Extract..... 1 bottle.
Vinegar............ 1 gal.
Worcestershire sauce 8 bottles.
Yeast Cakes........ 12 pkgs.

CAMP EQUIPMENT.

(*For One Field Party.*)

1 Chopping Bowl.
1 Bread Board
3 Wash Basins.
3 Pepper Boxes
1 Lunch Basket.
1 Broom.
1 Scrub Brush.
1 Biscuit Cutter.
10 yds. Canvas.
2 Can Openers.
1 Alarm Clock.
1 Collander.
3 Candle Sticks.
1 Coffee Mill.
24 Coffee Cups
24 Enamelware Pint Cups.
3 Tin Pot Covers.
1 Cake Turner.
2 Dippers.
2 Three cornered files.
1 Flat File.
1 Flesh Fork.
36 Forks.
1 Carving Fork.
1 Grindstone.
2 Griddles.
3 Butcher Knives.
1 Chopping Knife.
1 Carving Knife.
36 Knives.
4 3-Qrt. Pans.
4 4-Qrt. Pans.
4 6-Qrt. Pans.
18 Pint Pans.
6 3-Gal. Galvanized Water Pails.
36 Enamelware Plates.
12 Enamelware Pie Plates.
2 Iron Pots.
1 2-Gal Coffee Pot.
1 2-Gal. Tea Pot.
1 Potato Masher
4 Pieces Stove Pipe, with detachable dampers.
16 Pieces Stove Pipe, without dampers.
(Pipe to telescope.)
10 Roof Tins for Tents.
1 Pick and Handle.
100 feet ¾″ Manilla Rope
1 Rolling Pin.
1 Handsaw.
1 Saw Set.
1 Claw Hammer.
1 Trase.
1 ½″ Bit.
1 ¾″ Bit.
1 Large Screwdriver.
1 Spoke Shave.
1 Cross-Cut Saw.
1 Meat Saw.
1 Bundle Sail Twine and Needles.

1 Sail Palm.
1 Sieve.
4 Stoves, Sheet Iron
1 Cook Stove, No. 8 or 9.
1 Spade.
1 Round mouthed Shovel.
3 Enamelware Stew Kettles.
1 Tea Kettle.
3 Stand lamps and six chimneys
2 Mess Chests.
1 Monkey Wrench.
5 lbs. 10d nails.
1 Nutmeg Grater.
10 Yds. Table Oilcloth.
2 Stew Pans.
4 Drip Pans, 12 x 17.
1 5-Gal. Dishpan.
1 5-Gal. Bread Pan
1 Large Frying Pan.
1 Small Frying Pan.
4 Large Iron Spoons, 12″.
36 Teaspoons.
36 Tablespoons.
1 Soup Ladle.
1 Steel.
1 Steamer.
1 Tea Strainer.
5 Tents and Flies (14x14 pyramid 6″ walls or 14 x 16 "A" Tent, with 4′ 6″ walls).
1 Slatted Dinner Table.
1 Cook Table Top.
10 Yds. Towelling.
1 Washtub, Board and Boiler

ENGINEER EQUIPMENT AND STATIONERY.

(For One Field Party.)

1 Transit.
1 Level.
1 Chain.
4 Pickets.
2 Level Rods.
1 Barometer.
48 Thumb Tacks.
3 Camel Hair Brushes.
1 Steel Straight Edge (36″ nickle-plated).
1 Draughting Board and Trestles.
1 Stationery Chest, Tray and Board.
2 Hand Axes and extra handle
3 to 6 axes and extra handles.
1 Hatchet.
1 Brush Hook,
2 50′ tapes in cases, 2 without cases.
12 Blotters.
12 Papers 8 oz. tinned tacks.
2 Balls Twine.
1 Sounding Rod, 3 joints, 8′ each.
6 6-H Pencils.
12 4-H Pencils.
12 2-H Pencils.
12 Timber Leads.
2 Packages Large Manilla Envelopes.
2 Packages small Manilla Envelopes.
6 Penholders.

1 Box Assorted Pens.
1 Inkstand.
3 Pads Letter Paper.
2 Pyramids Pins.
6 Pencil Erasers.
6 Ink Erasers.
1 Bottle mucilage.
2 Bottles India Ink (Higgin's)
1 Bottle Green Ink (Higgin's)
1 Bottle Red Ink, (Higgin's)
2 Bottles Brown Ink (Higgin's).
1 Pint Bottle Writing Fluid.
24 Shipping Tags.
12 Field Books (K. & E. 932)
6 Topography Books (Harrison No. 2920.)
3 Quires Wrapping Paper
6 Scratch Pads.
2 Quires Foolscap.
1 Box Paper Fasteners.
10 Yds Cross-Section Paper, 10ths.
30 Yds Drawing Paper, 36".
1 Stylus Book with Carbons.
24 Sheets Time Report Forms.
1 Block Receipt Forms.
1 Box Assorted Rubber Bands
1 Roll Plate "A" Profile Paper, half width.
1 Roll Tracing Cloth, 36".
1 Chain Repairer

INSTRUCTIONS FOR USE OF SPIRAL.

THIS SPIRAL IS BASED ON THE FOLLOWING PRINCIPLES.

1. *The spiral is twice the length of the circular curve which it replaces.*
2. *The total angle of the spiral equals the central angle of that part of the circular curve which it replaces.*
3. *The deflection angles from the beginning of the spiral to any points on same vary as the square of the distance from the B.S. to the given points, measured along the spiral.*
4. *The offsets to the spiral from the tangent produced vary as the cube of the distance measured along the tangent (approximate).*
5. *Length of spiral should be 100 feet multiplied by degree of the circular curve to be spiralled. Spirals greater than 400 feet or less than 100 feet will not be used. When broken alignment is necessary, and the tangents are too short to allow use of 400 foot spiral, 200 or 100 foot spirals may be used.*
6. *The curvature of the **400** foot spiral increases one degree per 100 feet of length for curves up to a 4°; for curves sharper than a 4° curvature of spiral increases $\frac{1^\circ \times \text{degree of curve}}{4}$ per hundred feet of length.*

   *The curvature of **200** foot spiral increases one degree per 50 feet of length for curves up to a 4°, for curves sharper than 4°, curvature of spiral increases $\frac{1^\circ \times \text{degree of curve}}{4}$ per fifty feet of length.*

   *The curvature of the **100** foot spiral increases one degree per 25 feet of length for a 4° curve (which is the minimum used): for curves sharper than a 4° curvature of spiral increases $\frac{1^\circ \times \text{degree of curve}}{4}$ per twenty five feet of length.*
7. *When curvature of spiral exceeds 5°, fifty foot chords should be used in running in same.*

TO FIND DEFLECTION ANGLES FOR SPIRAL

A. *With instrument at B.S deflection angle to set any point in 400 foot spiral up to 4° curve may be taken directly from Table 3: for curves sharper than 4° multiply deflection angle in Table 3 by $\frac{\text{degree of curve to be spiralled}}{4}$*

For 200 foot spiral deflection angle to set any point equals deflection angle for 400 foot spiral multiplied by 2.

For 100 foot spiral deflection angle to set any point equals deflection angle for 400 foot spiral multiplied by 4.

B. *With instrument at any point on spiral and backsight on B.S. or any other point between instrument and B.S deflection angle to turn tangent equals deflection angle for a curve corresponding to the curvature of the spiral at instrument minus deflection angle taken from table 3 for the same distance. Deflection angle from tangent to set any point ahead of instrument equals* *deflection angle for a curve corresponding to the curvature of the spiral at the instrument plus deflection angle taken from Table 3 for given distance.*

C. *With instrument at E.C. deflection angle from tangent to set any point in spiral equals deflection angle of the circular curve for the given distance minus deflection angle taken from Table 3 for same distance.*

D. *With instrument at any point on spiral and backsight on E.C. or any other point between instrument and E.C. deflection angle to turn tangent equals deflection for a curve corresponding to the curvature of the spiral at instrument for the given distance plus the deflection angle taken from Table 3 for the same distance. Deflection angle from tangent to set any point ahead of instrument equals deflection angle for a curve corresponding to the curvature of the spiral at the instrument minus deflection angle taken from Table 3 for the given distance.*

TO FIND SUB-TANGENT AND LENGTH OF SPIRALLED CURVE.

Sub-tangent for spiralled curve equals sub-tangent for simple curve of same total intersection angle plus one half length of spiral plus correction to be taken from Table 2. Total length of spiralled curve equals length of simple curve plus one half length of spirals.

EXAMPLE 1 - TO SPIRAL A SIMPLE CURVE

Let bearing of tangent at B.S. be N. 54°50'W. and bearing of tangent at E.S. be N. 2°02'W., then total intersection angle equals 52°48'.

Let degree of curve be 4°, then length of spiral = 400 ft. (Sect. 5)

Central Angle of spiral = ½ angle of 4° curve for 400' = 8° (Sect. 1 & 2)

Total length of curve $= 100\left(\frac{52\cdot8}{4}\right) + 400 = 1720'$.

Length circular curve $= 1720 - 800 = 920'$.

Let B.S. be at station 125+23, then B.C. will be at sta. 129+23, E.C. will be at sta. 138+43, and E.S. at sta. 142+43.

Sub-tangent = sub-tangent for circular curve of 52°46' $+ \frac{\text{length of spiral}}{2}$ *+ correction to be taken from Table 2* $= \frac{2844\cdot2}{4} + \frac{400}{2} + 2\cdot2$ *(by interpolation) = 913·3' distance from B.S. to P.I. This distance to be used for plotting or if P.I should be set.*

With instrument at B.S. to set station 126+00 deflection angle for 77 ft. = 0°06' (Table 3). To set hub at 126+23 deflection angle for 100 ft. = 0°10' (Table 3), 126+23 being 100' from B.S. degree of curvature at this point equals 1°.

With instrument at station 126+23 and backsight on B.S. to turn tangent deflection angle equals deflection angle for 1° curve for 100 ft. minus deflection angle from Table 3 for same distance = 30'−10' = 20'. To set station 127+00 deflection angle from tangent equals deflection angle for 1° curve for 77 ft. plus deflection angle taken from Table 3 for same distance = 23'+06' = 29'. To set hub at 127+73 deflection angle from tangent equals deflection angle for 1° curve for 150 ft. plus deflection angle taken from Table 3 for same distance = 45′ + 22·5′ = 1° 07·5′. 127·73 being 250 ft. from B.S. degree of curvature at this point = 2° 30′.

With instrument at station 127+73 and backsight on station 126+23 to turn tangent deflection angle equals deflection angle for 2° 30′ curve for 150 feet minus deflection angle taken from Table 3 for same distance = 1° 52·5′ − 22·5′ = 1° 30′. To set hub at station 129+23 = B.C. deflection angle from tangent equals deflection angle for 2° 30′ curve for 150 ft. plus deflection angle taken from Table 3 for same distance = 1° 52·5′ + 22·5′ = 2° 15′. Station 129+23 being 400 ft from B.S. degree of curvature at this point equals 4°.

With instrument at B.C. and backsight on station 127+73 deflection angle to turn tangent equals deflection angle for 4° curve for 150 feet minus deflection angle taken from Table 3 for same distance = 3° − 22·5′ = 2° 37·5′. To set hub at station 134+00 deflection angle from tangent = 9° 32·5′.

With instrument at station 134+00 and backsight on B.C. to turn tangent deflection angle equals 9° 32·5′. To set hub at station 138+43 = E.C. deflection angle from tangent equals 8° 51·5′.

With instrument at E.C. and backsight on station 134+00 deflection angle to turn tangent equals 8° 51·5′. To set hub at station 139+43 deflection angle from tangent equals deflection angle for 4° curve for 100 ft. minus deflection angle taken from Table 3 for same distance = 2° 0′ − 10′ = 1° 50′. Station 139+43 being 100 ft. from E.C. degree of curvature of spiral at this point equals 3°.

With instrument at station 139+43 and backsight on E.C. to turn tangent deflection angle equals deflection angle for 3° for 100 ft. plus deflection angle taken from Table 3 for same distance = 1° 30′ + 10′ = 1° 40′. To set hub at station 140+93 deflection angle from tangent equals deflection angle for 3° curve for 150 feet minus deflection angle taken from Table 3 for same distance = 2° 15′ − 22·5′ = 1° 52·5′. Station 140+93 being 250 feet from E.C. degree of curvature of spiral at this point equals 1° 30′.

With instrument at 140+93 and backsight on 139+43 to turn tangent deflection angle equals deflection angle for 1° 30′ curve for 150 feet plus deflection angle taken from Table 3 for same distance = 1° 07·5′ + 22·5′ = 1° 30′. To set hub at station 142+43 = E.S. deflection angle from tangent equals deflection angle for 1° 30′ curve for 150 feet minus deflection angle taken from Table 3 for same distance. = 1° 07·5′ − 22·5′ = 0° 45′.

With instrument at E.S. and backsight on station 140+93 to turn tangent deflection angle equals deflection angle taken from Table 3 for 150 feet = 22·5′ (see transit notes).

EXAMPLE 2. – TO SPIRAL A COMPOUND CURVE

A spiral between the two simple curves of a compound curve will be run in the same manner as the ordinary spiral, always taking into consideration the degree of curvature at the beginning of spiral, and adding or subtracting the spiral deflections from the curve deflections, adding if the curvature is to increase, and subtracting if the curvature is to decrease.

Let station 31+72.5 = P.C.C. between a 4° and a 10° curve. It is required to run in a spiral between them. Difference in degree of curvature of the two simple curves equals 6°, therefore spiral to be used is similar to that used for a simple 6° curve.

Length = 400 ft. Central angle due to spiral = $(4^\circ \times 2) + (10^\circ \times 2) - (4^\circ \times 4) = 12^\circ$.

B.C.S. = 31+72.5 − 200 = 29+72.5, say 29+72

E.C.S. = 29+72 + 400 = 33+72.

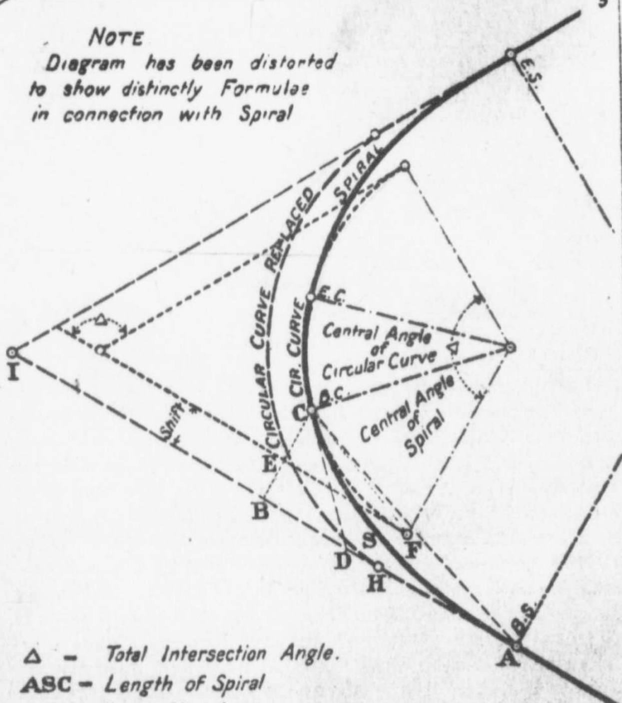
With instrument at 29+72 = B.C.S. to set station 30+00 deflection angle from tangent = deflection angle for 4° curve for 28′ + (deflection angle taken from Table 3 for same distance × 6/4) = 33.6 + $(0\frac{3}{4}' \times \frac{6}{4}) = 34\frac{3}{4}$ nearly. To set hub at 31+32 deflection angle from tangent equals deflection angle for 4° curve for 150 ft. plus (deflection angle taken from Table 3 for same distance × 6/4) = 3° + (22.5 × 6/4) = 3°34′. Station 31+22 being 150 ft. from B.C.S. degree of curvature at this point = $4^\circ + (1 \times \frac{6}{4} \times 1.5) = 6^\circ 15'$.

With instrument at 31+22 and backsight on B.C.S. to turn tangent deflection angle equals deflection angle for 6°15′ curve for 150 ft. minus (deflection angle taken from Table 3 for same distance × 6/4) = 4° 41.25′ − 34′ = 4°07′. To set hub at station 32+72 deflection angle from tangent equals deflection angle for 6°15′ curve for 150 ft. plus (deflection angle taken from Table 3 for same distance × 6/4) = 4°41.25′ + 34′ = 5°15′. Station 32+72 being 300 ft. from B.C.S. degree of curvature at this point = $4^\circ + (1 \times 6/4 \times 3) = 8^\circ 30'$.

With instrument at 32+72 and backsight on 31+22 to turn tangent deflection angle equals deflection angle for 8°30′ curve for 150 ft. minus deflection angle taken from Table 3 for same distance = 6°22.5′ − 33.5′ = 5°49′. To set hub at 33+72 deflection angle from tangent equals deflection angle for 8°30′ curve for 100 ft. plus (deflection angle taken from Table 3 for same distance × 6/4) = 4°15′ + (10 × 6/4) = 4°30′. Station 33+72 being 400 feet from B.C.S. curvature at this point equals $4^\circ + (4^\circ \times 6/4) = 10^\circ$

With instrument at 33+72 = E.C.S. and backsight on 32+72 to turn tangent deflection angle equals deflection angle for 10° curve for 100 feet minus (deflection angle taken from Table 3 for same distance × 6/4) = 5° − 15′ = 4°45′.

NOTE
Diagram has been distorted to show distinctly Formulae in connection with Spiral



Δ – *Total Intersection Angle.*

ASC – *Length of Spiral*

AC – *Long Chord.*

AD – *1st Sub Tangent of Spiral.*

DC – *2nd " " " "*

EB–BC–EC – *Shift – Sine of Defl. Angle for Centre of Spiral × Length of Spiral.*

AI – *Sub. Tan* – $HI + \frac{1}{2}ASC + \left\{(EB \times \tan \frac{1}{2}\Delta) - (\frac{1}{2}ASC + EF - AB)\right\}$

$\because \left\{(EB \times \tan \frac{1}{2}\Delta) - (\frac{1}{2}ASC + EF - AB)\right\}$ – *Correction in Table 2*

$\therefore$ *Sub Tan* – $HI + \frac{1}{2}ASC$ + *Correction from Table 2.*

TABLE 1.

ELEMENTS OF THE SPIRAL

Degree of Curve	400 FT. SPIRAL				200 FT. SPIRAL				100 FT. SPIRAL			
	Shift	1st Sub Tan.	2nd Sub Tan	Long Chord	Shift	1st Sub Tan.	2nd Sub Tan.	Long Chord	Shift	1st Sub Tan	2nd Sub. Tan	Long Chord
1°	·07	66·67	33·33	100·00								
1°30′	·25	100·00	50·00	150·00								
2°	·58	133·34	66·67	199·99	·14	66·67	33·33	100·00				
2°30′	1·12	166·69	83·35	249·96	·28	83·34	41·67	125·00				
3°	1·96	200·08	100·07	299·95	·49	100·00	50·01	150·00				
3°30′	3·08	233·48	116·81	349·84	·77	116·70	58·35	175·00				
4°	4·64	266·93	133·61	399·67	1·16	133·36	66·70	199·96	·29	66·67	33·34	100·00
5°	5·81	267·07	133·76	399·49	1·45	133·39	66·72	199·94	·36	66·68	33·34	100·00
6°	7·01	267·23	133·94	399·22	1·75	133·42	66·75	199·92	·44	66·68	33·36	100·00
7°	8·13	267·46	134·18	398·95	2·03	133·44	66·78	199·89	·51	66·68	33·35	99·99
8°	9·28	267·70	134·43	398·65	2·32	133·46	66·81	199·84	·58	66·69	33·36	99·99
9°	10·44	267·97	134·72	398·30	2·61	133·50	66·84	199·80	·65	66·69	33·36	99·98
10°	11·59	268·29	135·01	397·89	2·90	133·55	66·89	199·76	·73	66·70	33·37	99·98
11°	12·74	268·65	135·43	397·46	3·19	133·60	66·94	199·71	·80	66·70	33·37	99·97
12°	13·90	269·02	135·84	396·97	3·48	133·65	66·99	199·66	·87	66·72	33·38	99·97
13°	15·04	269·44	136·28	396·46	3·76	133·70	67·04	199·59	·94	66·72	33·38	99·96
14°	16·18	269·90	136·76	395·89	4·04	133·75	67·09	199·53	1·01	66·73	33·39	99·95

TABLE 2

(PLUS) CORRECTION FOR SUB TAN.

Spiral	Intersection Angle	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°
400 FT SPIRAL	5°	·01												
	10°	·03	·15											
	20°	·08	·33	·66	·78									
	30°	14	·51	1·09	1·32	1·49	1·69							
	40°	·19	·69	1·54	1·87	2·16	2·47	2·73	2·98	3·21				
	50°	·25	·89	2·01	2·47	2·88	3·30	3·68	4·05	4·40	4·73	5·04		
	60°	·31	1·11	2·53	3·11	3·66	4·20	4·71	5·21	5·68	6·15	6·59	6·99	7·38
	70°	·38	1 35	3·10	3·83	4·52	5·20	5·85	6·49	7·11	7·71	8·29	8·84	9·37
	80°	·48	1·63	3·75	4·64	5·49	6·33	7·14	7·94	8·72	9·48	10·22	10·93	11·62
	90°	·56	1·94	4·48	5·57	6·62	7·64	8·63	9·62	10·58	11·53	12·46	13·35	14·22
	100°	·57	2·32	5·39	6·68	7·96	9·20	10·41	11·62	12·80	13·97	15·13	16·23	17·32
	110°	·81	2·78	6·50	8·06	9·62	11·12	12·60	14·09	15·54	16·99	18·41	19·79	21·42
	120°	·99	3·38	7·91	9·82	11·75	13·59	15·42	17·26	19·06	20·86	22·64	24·36	26·06
200 FT SPIRAL	5°	·00	02											
	10°	·01	04	·07	·08									
	20°	·02	·09	·18	·21	·25	·27	·27	·29	·31				
	30°	·04	·13	·28	·34	·41	·45	·48	·53	·58	·61	·66	·67	·68
	40°	·05	·18	·39	·48	·58	·65	·70	·78	·86	·92	·99	1·05	1·07
	50°	·07	·23	·51	·63	·76	·86	·94	1·05	1·15	1·24	1·34	1·41	1·48
	60°	·08	·28	·64	·79	·95	1·08	1·20	1·34	1·47	1·60	1·73	1·83	1·93
	70°	·10	·34	·78	·97	1·17	1·33	1·48	1·66	1·83	1·99	2·16	2·29	2·43
	80°	·12	·41	·94	1·18	1·41	1·61	1·81	2·02	2·23	2·43	2·64	2·82	2·99
	90°	·14	·49	1·13	1·40	1·69	1·94	2·18	2·44	2·70	2·94	3·20	3·42	3·64
	100°	·17	·58	1·36	1·68	2·03	2·33	2·62	2·94	3·26	3·55	3·87	4·14	4·42
	110°	·20	·70	1·63	2·03	2·44	2·81	3·17	3·56	3·94	4·30	4·69	5·03	5·37
	120°	·25	·85	1·98	2·47	2·97	3·43	3·88	4·35	4·82	5·27	5·75	6·17	6·60
100 FT SPIRAL	5°			·01	·01									
	10°			·02	·03	·04	·01	·01	·01					
	20°			·05	·06	·08	·05	·06	·07	·07	·06	·05	·06	·05
	30°			·08	·10	·12	·11	·12	·13	·14	·13	·14	·14	·14
	40°			·10	·13	·16	·16	·17	·19	·21	·21	·23	·23	·24
	50°			·13	·17	·21	·21	·23	·26	·28	·29	·32	·33	·34
	60°			·17	·21	·25	·27	·29	·33	·36	·38	·41	·43	·45
	70°			·20	·25	·31	·33	·37	·41	·45	·48	·52	·55	·58
	80°			·24	·30	·37	·40	·45	·50	·55	·59	·64	·68	·72
	90°			·29	·36	·44	·48	·54	·60	·67	·72	·78	·83	·88
	100°			·35	·43	·52	·58	·65	·73	·81	·87	·95	1·01	1·07
	110°			·41	·52	·63	·70	·79	·89	·98	1·06	1·15	1·23	1·31
	120°			·50	·62	·76	·85	·97	1·08	1·20	1·33	1·42	1·52	1·62

TABLE 3

DEFLECTIONS

Corresponding Curve	Length of Spiral		1	2	3	4	5	6	7	8	9
0·06	10	0·00	0·00	0·00	0·00¼	0·00¼	0·00¼	0·00¼	0·00¼	0·00¼	0·00½
0·12	20	0·00½	0·00½	0·00½	0·00½	0·00½	0·00½	0·00¾	0·00¾	0·00¾	0·00¾
0·18	30	0·01	0·01	0·01	0·01	0·01	0·01¼	0·01¼	0·01½	0·01½	0·01½
0·24	40	0·01½	0·01¾	0·01¾	0·01¾	0·02	0·02	0·02	0·02¼	0·02¼	0·02½
0·30	50	0·02½	0·02½	0·02¾	0·02¾	0·03	0·03	0·03	0·03¼	0·03¼	0·03½
0·36	60	0·03½	0·03¾	0·03¾	0·04	0·04	0·04¼	0·04½	0·04½	0·04½	0·04¾
0·42	70	0·05	0·05	0·05¼	0·05¼	0·05½	0·05½	0·05¾	0·06	0·06	0·06¼
0·48	80	0·06½	0·06½	0·06¾	0·07	0·07	0·07¼	0·07½	0·07½	0·07¾	0·08
0·54	90	0·08	0·08¼	0·08½	0·08½	0·08¾	0·09	0·09¼	0·09½	0·09½	0·09¾
1·00	100	0·10	0·10¼	0·10½	0·10½	0·10¾	0·11	0·11¼	0·11½	0·11¾	0·12
1·06	110	0·12	0·12¼	0·12½	0·12¾	0·13	0·13¼	0·13½	0·13¾	0·14	0·14¼
1·12	120	0·14½	0·14½	0·15	0·15	0·15¼	0·15½	0·16	0·16¼	0·16½	0·16¾
1·18	130	0·17	0·17¼	0·17½	0·17¾	0·18	0·18¼	0·18½	0·18¾	0·19	0·19¼
1·24	140	0·19½	0·20	0·20¼	0·20½	0·20¾	0·21	0·21¼	0·21½	0·22	0·22¼
1·30	150	0·22½	0·22¾	0·23	0·23½	0·23¾	0·24	0·24¼	0·24¾	0·25	0·25¼
1·36	160	0·25½	0·26	0·26¼	0·26½	0·27	0·27¼	0·27½	0·28	0·28¼	0·28½
1·42	170	0·28¾	0·29¼	0·29½	0·30	0·30¼	0·30½	0·31	0·31¼	0·31¾	0·32
1·48	180	0·32¼	0·32¾	0·33	0·33½	0·34	0·34¼	0·34½	0·35	0·35¼	0·35¾
1·54	190	0·36	0·36½	0·37	0·37¼	0·37½	0·38	0·38½	0·39	0·39¼	0·39½
2·00	200	0·40	0·40½	0·41	0·41¼	0·41½	0·42	0·42½	0·42¾	0·43¼	0·43¾
2·06	210	0·44	0·44½	0·45	0·45¼	0·45¾	0·46¼	0·46¾	0·47	0·47½	0·48
2·12	220	0·48½	0·48¾	0·49¼	0·49¾	0·50¼	0·50½	0·51	0·51½	0·52	0·52½
2·18	230	0·53	0·53½	0·53¾	0·54¼	0·54¾	0·55¼	0·55¾	0·56¼	0·56½	0·57
2·24	240	0·57½	0·58	0·58½	0·59	0·59½	1·00	1·00½	1·01	1·01½	1·02
2·30	250	1·02½	1·03	1·03½	1·04	1·04½	1·05	1·05½	1·06	1·06½	1·07
2·36	260	1·07½	1·08	1·08½	1·09¼	1·09¾	1·10¼	1·10¾	1·11¼	1·11¾	1·12½
2·42	270	1·13	1·13½	1·14	1·14½	1·15	1·15½	1·16¼	1·16¾	1·17¼	1·17¾
2·48	280	1·18½	1·19	1·19½	1·20	1·20¾	1·21¼	1·21¾	1·22½	1·23	1·23½
2·54	290	1·24	1·24¾	1·25¼	1·26	1·26½	1·27	1·27½	1·28¼	1·28¾	1·29½
3·00	300	1·30	1·30½	1·31¼	1·31¾	1·32½	1·33	1·33½	1·34½	1·35	1·35½
3·06	310	1·36	1·36¾	1·37¼	1·38	1·38½	1·39¼	1·40	1·40½	1·41	1·41¾
3·12	320	1·42½	1·43	1·43¾	1·44¼	1·45	1·45¾	1·46¼	1·47	1·47½	1·48¼
3·18	330	1·49	1·49½	1·50¼	1·51	1·51½	1·52¼	1·53	1·53½	1·54¼	1·55
3·24	340	1·55½	1·56¼	1·57	1·57½	1·58¼	1·59	1·59¾	2·00½	2·01	2·01¾
3·30	350	2·02¼	2·03¼	2·04	2·04½	2·05¼	2·06	2·06¾	2·07½	2·08¼	2·09
3·36	360	2·09½	2·10¼	2·11	2·11¾	2·12½	2·13¼	2·14	2·14¾	2·15½	2·16¼
3·42	370	2·17	2·17½	2·18¼	2·19	2·19¾	2·20¾	2·21¼	2·22	2·22¾	2·23½
3·48	380	2·24½	2·25¼	2·26	2·26¾	2·27½	2·28¼	2·29	2·29¾	2·30½	2·31¼
3·54	390	2·32	2·33	2·33¾	2·34½	2·35¼	2·36	2·36¾	2·37½	2·38½	2·39¼
4·00	400	2·40									

METHOD OF KEEPING TRANSIT

Station	Description	Angle Deflection	Angle Total	Bearing Calculated	Bearing Magnetic
		8° 51½'	44° 48'	N.10° 02' W.	N.10° 00 W.
138+43	E.C.	0° 51½'	35° 56½'		
138+00		2° 00'	35° 05'		
137+00		2° 00'	33° 05'		
136+00		2° 00'	31° 05'		
135+00		2° 00'	29° 05'		
		9° 32½'	27° 05'	N.27° 45' W.	N.27° 45' W
134+00		2° 00'	17° 32½'		
133+00		2° 00'	15° 32½'		
132+00		2° 00'	13° 32½'		
131+00		2° 00'	11° 32½'		
130+00		1° 32½'	9° 32½'		
	36° 48'	2° 37½'	8° 00	N.46° 50' W.	N.46° 45' W
129+23	B.C. 4° R.	2° 15'	5° 22½'		
129+00		1° 51	4° 58½'		
128+00		0° 21	3° 28½'		
		1° 30	3° 07½'	N.51° 42½' W.	N.51° 45'
127+73	2° 30' C.	1° 07½'	1° 37½'		
127+00		0° 29	0° 59'		
		0° 20	0° 30'	N. 54° 20' W.	N.54° 15 W.
126+23	1° C.	0° 10	0° 10'		
126+00		0° 06	0° 06'		
125+23	B.S.				
				N.54° 50' W.	N.54° 45 W.

NOTES

138+41

137+23

135+70

134+60

4° C.

52° 48' R

S.T. 913.3

129+90

129+23

9

ANSIT
g
lagnetic

10° 00 W.

27° 45 W

46° 45 W

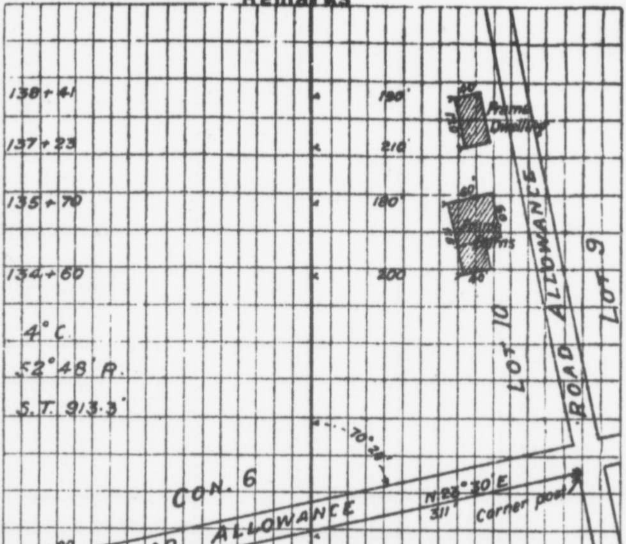
51° 45

54° 15 W.

54° 45 W.

NOTES ON LOCATION

Remarks



NOTE — When instrument is set up on a curve, always read the intersection angles with roads, land lines etc., from the tangent to the curve at the instrument.

7-30 A.M.
27/12/05.

Station	Description	Angle: Deflection	Angle: Total	Bearing: Calculated	Bearing: Magnetic
201+24	B.S				
166+43					
171+18					
163+32					
151+10					
		0° 22½'	52° 48'	N.2°02'W	N.2°00'W
142+43	E.S.	0° 45'	52° 25½'		
142+00		0° 36½'	52° 17'		
141+00		0° 03	51° 43½'		
		1° 30'	51° 40½'	N.3°09½'W	N.3°15'W
140+93	1°30' C.	1° 52½'	50° 10½'		
140+00		0° 48	49° 06'		
		1° 40	48° 18'	N.6°32 W	N.6°30'W
139+43	3° C.	1° 50'	46° 38'		
139+00		1° 05	45° 53'		
			44° 48'	N.10°02 W	N.10°00'W

Point on r

Tack in roo

Rain stop

Rain start

ng
Magnetic

N. 2° 00' W.

N. 3° 15' W.

N. 6° 30' W.

N. 10° 00' W.

L.

Remarks.

5-45 P.M.

Point on rock

Tack in root of spruce tree

Rain stops

Rain starts.

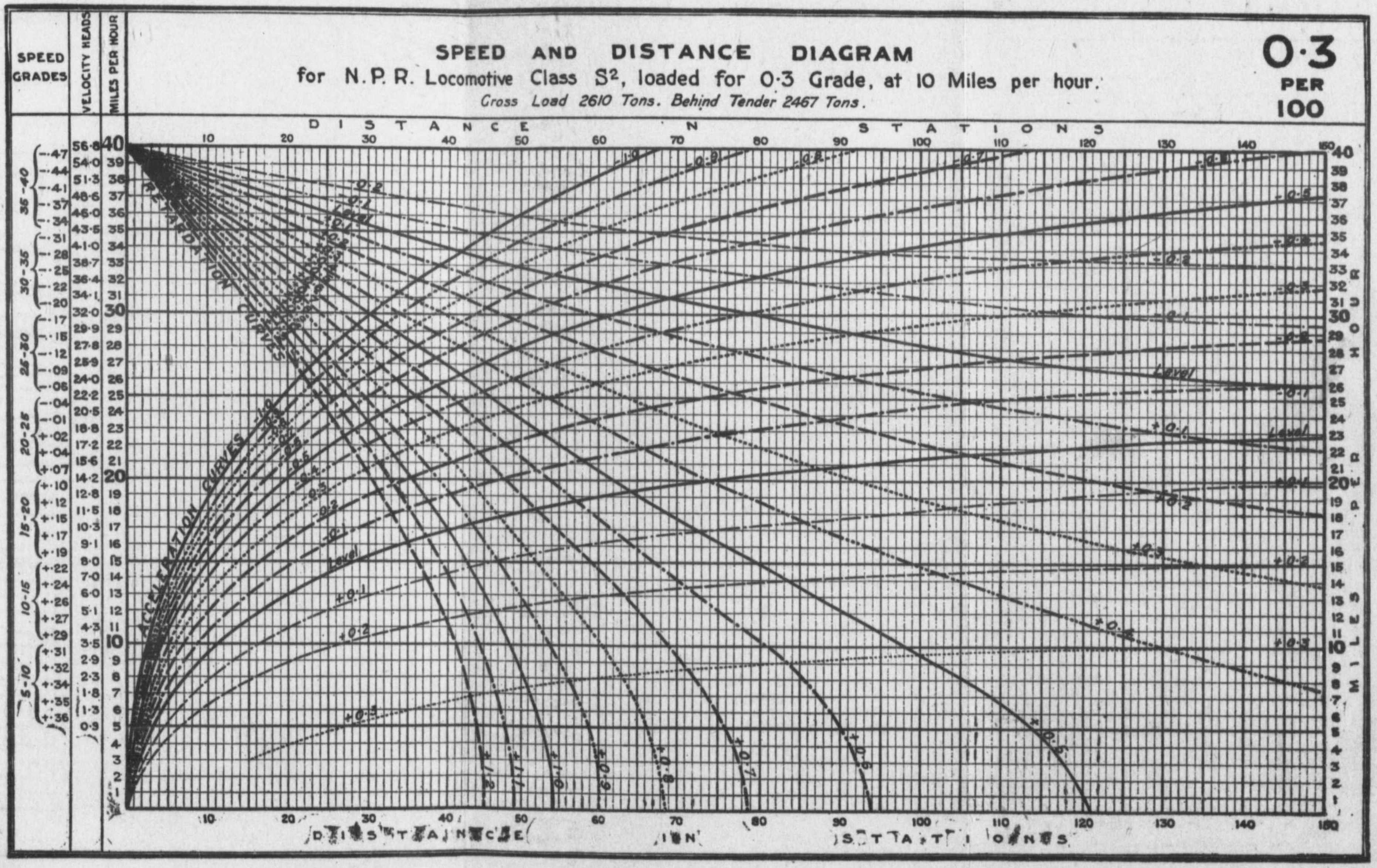
27/12/05.

SPEED AND DISTANCE DIAGRAM

for N.P.R. Locomotive Class S^2, loaded for 0·3 Grade, at 10 Miles per hour.

Cross Load 2610 Tons. Behind Tender 2467 Tons.

0·3 PER 100



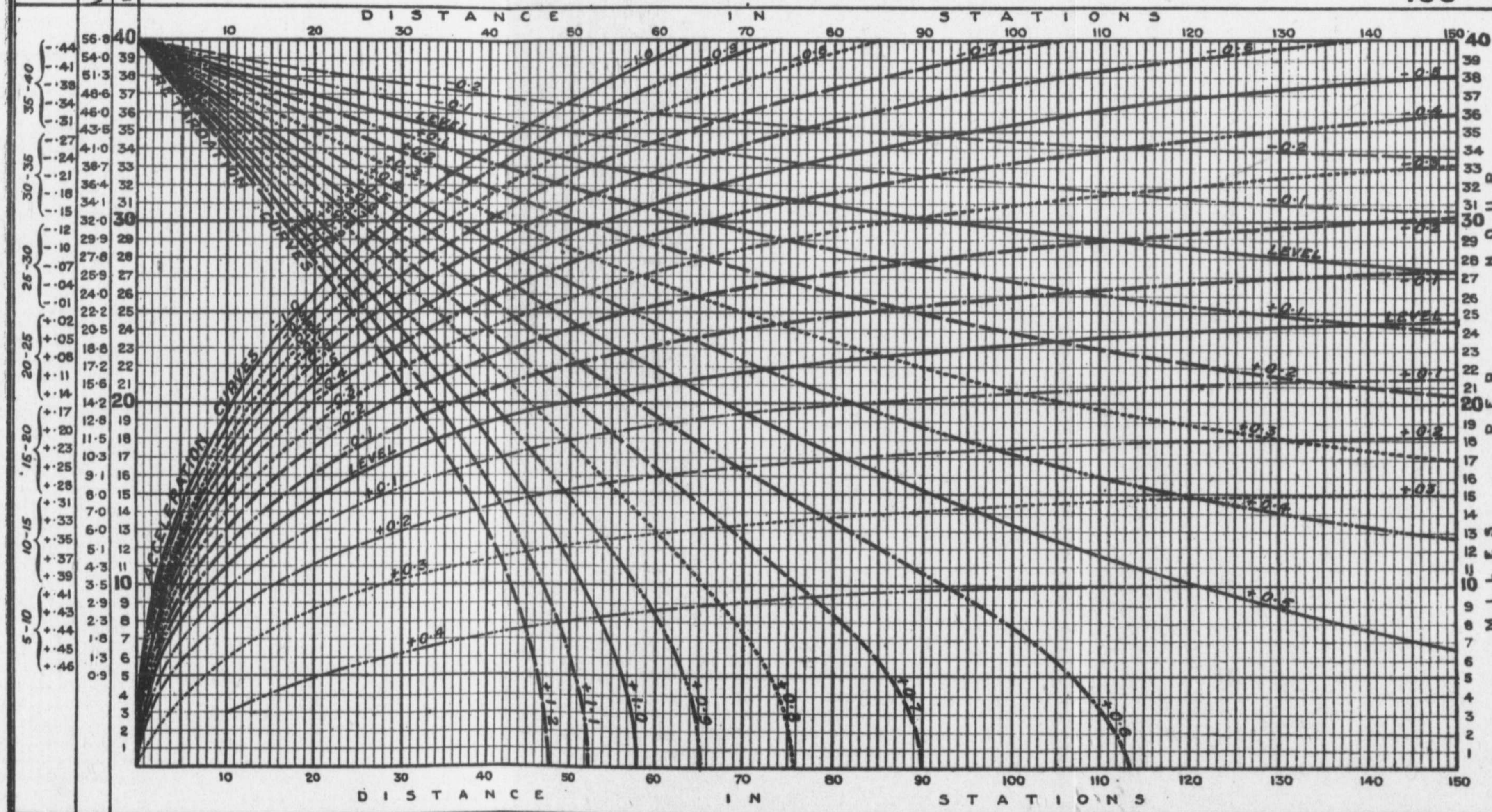
SPEED GRADES | VELOCITY HEADS | MILES PER HOUR

SPEED AND DISTANCE DIAGRAM

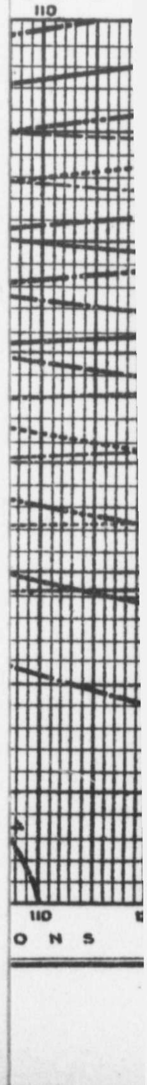
for N. P. R. Locomotive Class S[2], loaded for 0·4 Grade, at 10 Miles per hour.

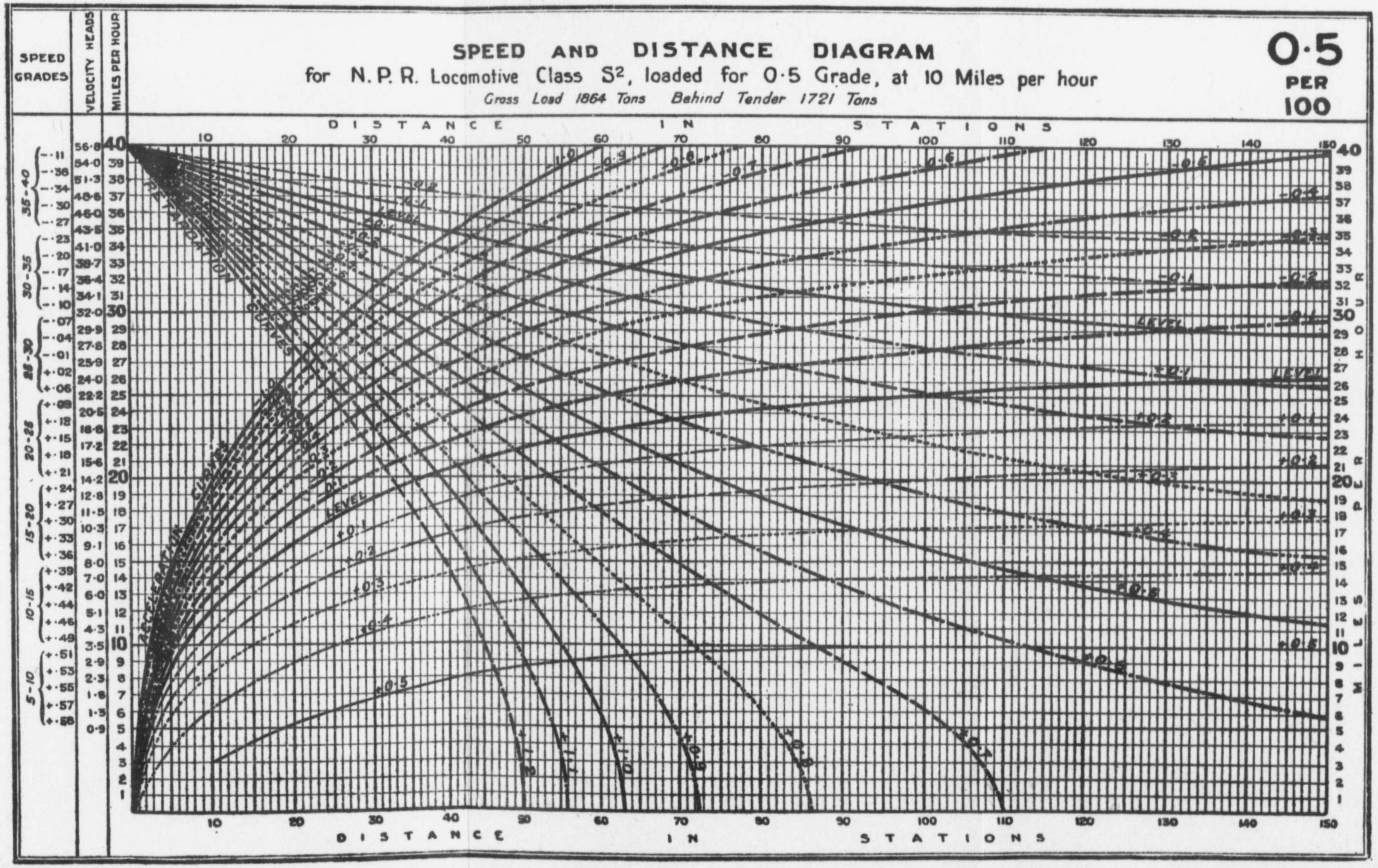
Gross Load 2175 Tons Behind Tender 2032 Tons

0·4 PER 100

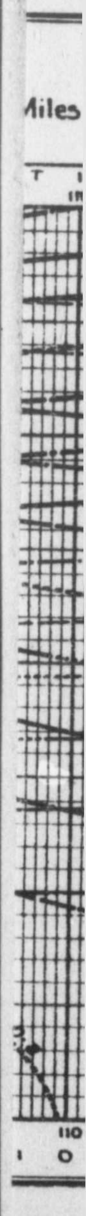


les per h





SPEED AND DISTANCE DIAGRAM
for N. P. R. Locomotive Class S2, loaded for 0·5 Grade, at 10 Miles per hour
Gross Load 1864 Tons Behind Tender 1721 Tons
0·5 PER 100
SPEED GRADES
VELOCITY HEADS
MILES PER HOUR
DISTANCE IN STATIONS
ACCELERATION CURVES
RETARDATION CURVES
LEVEL
MILES PER HOUR

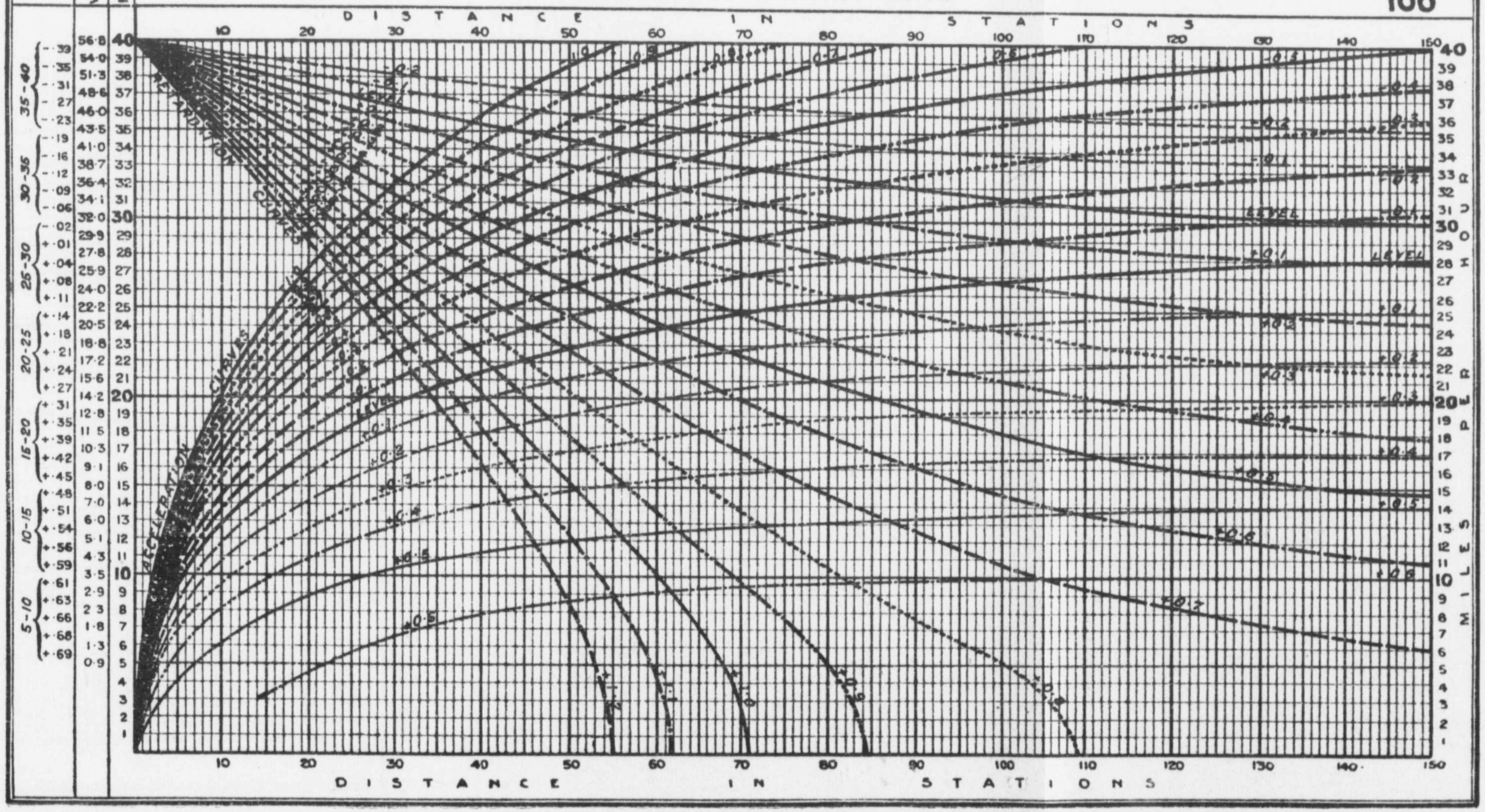

Miles
110

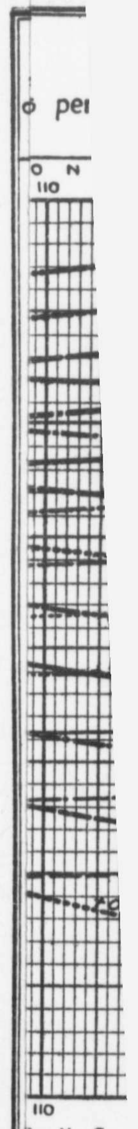
SPEED AND DISTANCE DIAGRAM

for N.P.R. Locomotive Class S^2, loaded for 0·6 Grade, at 10 Miles per hour.

Gross Load 1631 Tons Behind Tender 1488 Tons

0·6 PER 100



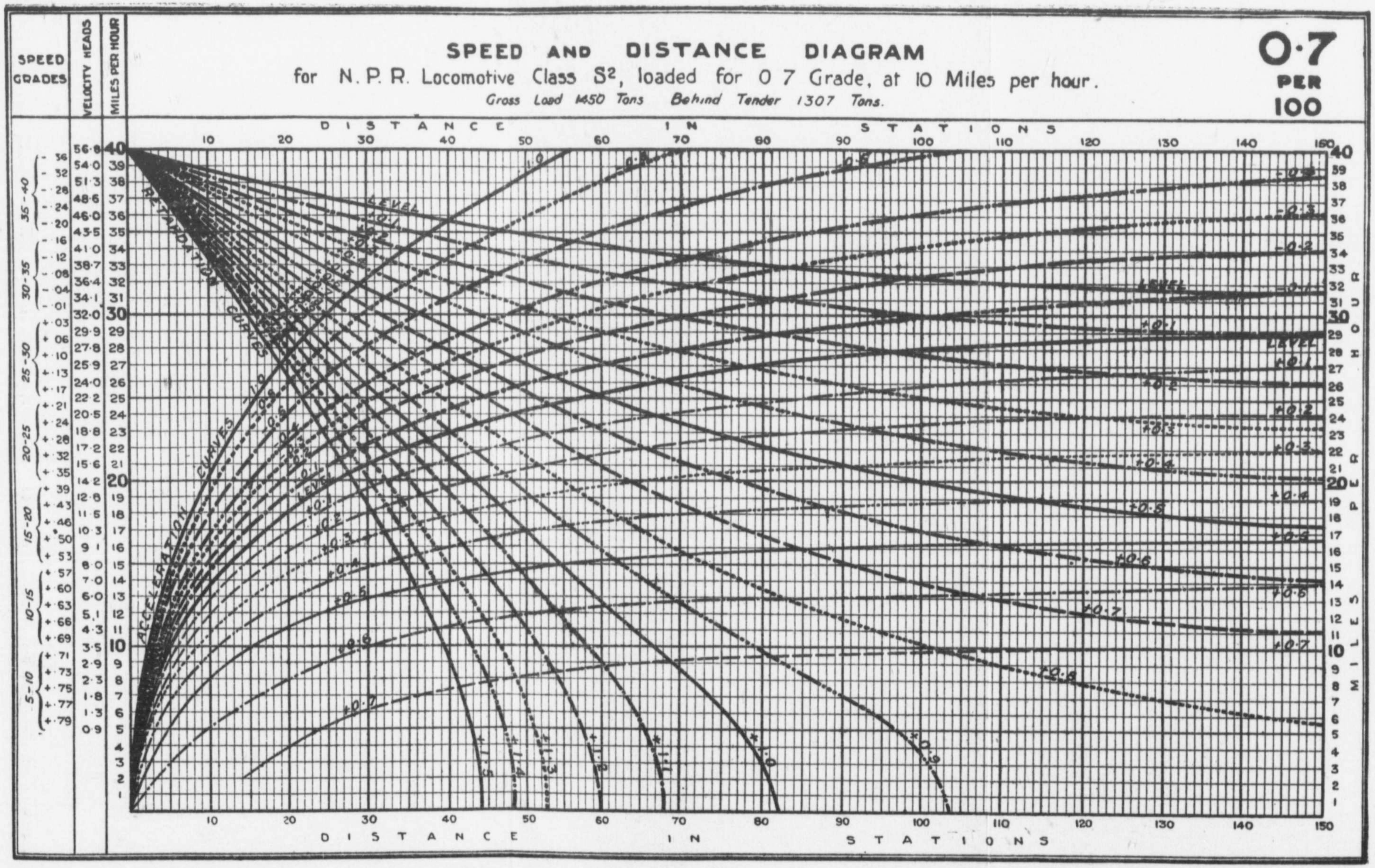

O N
110
110
N S

SPEED AND DISTANCE DIAGRAM

for N. P. R. Locomotive Class S^2, loaded for 0 7 Grade, at 10 Miles per hour.

Gross Load 1450 Tons Behind Tender 1307 Tons.

0·7 PER 100

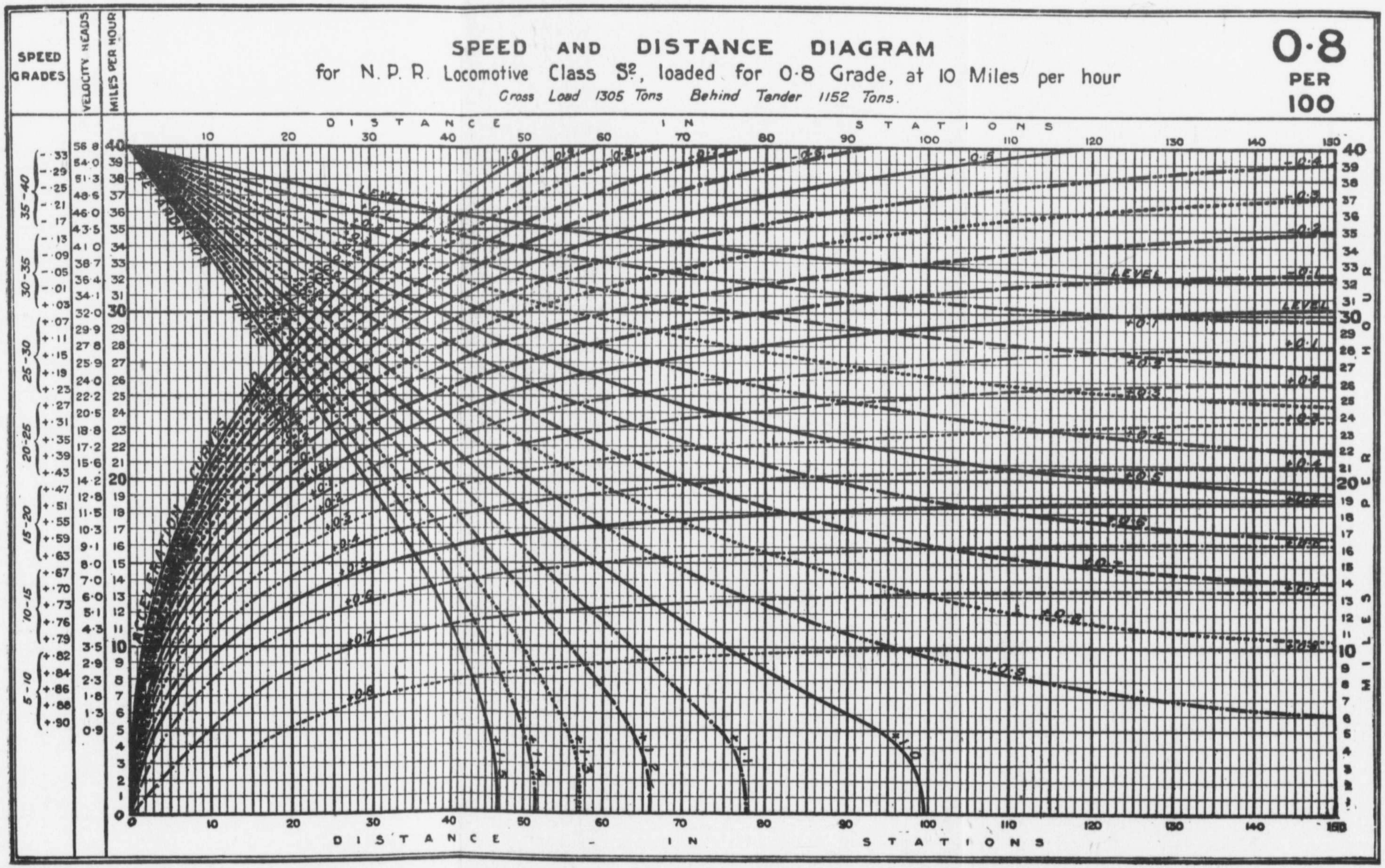


SPEED AND DISTANCE DIAGRAM

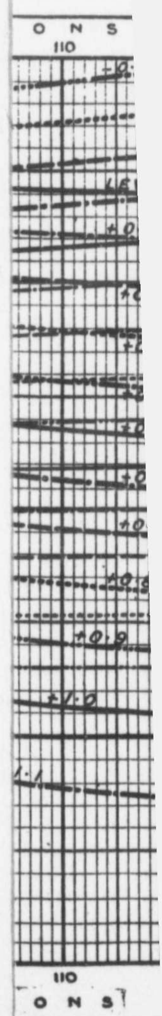
for N. P. R. Locomotive Class S^2, loaded for 0·8 Grade, at 10 Miles per hour

Gross Load 1305 Tons Behind Tender 1152 Tons.

0·8 PER 100



Miles per



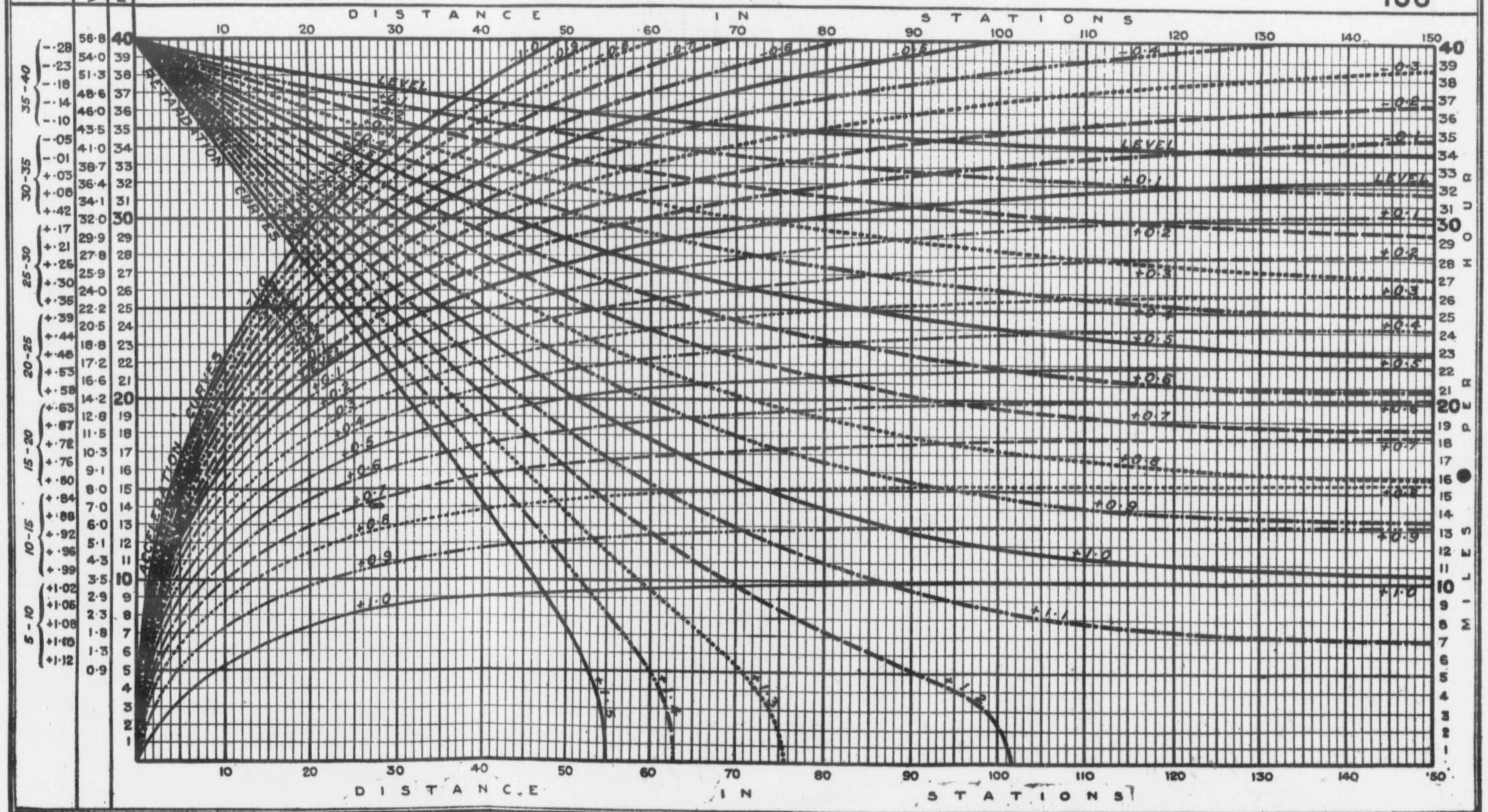
SPEED GRADES	VELOCITY HEADS	MILES PER HOUR	

SPEED AND DISTANCE DIAGRAM

for N.P.R. Locomotive Class S^2, loaded for 1·0 Grade, at 10 Miles per hour

Cross Load 1087 Tons Behind Tender 944 Tons.

1·0 PER 100



CANADIAN PACIFIC RAILWAY

STATEMENT SHOWING VALUE AND COST OF GRADE REVISIONS

..................................DIVISION ....SECTION OR BRANCH.

from..to..Miles

TERMINAL POINTS	PROPOSITION	LOCOMOTIVE POWER	DIRECTION	RULING GRADE Present	RULING GRADE Proposed	THROUGH FREIGHT TRAFFIC fr.........190 to.........190	RATING Present	RATING Proposed	NUMBER OF TRAINS EACH WAY Present	NUMBER OF TRAINS EACH WAY Proposed	NUMBER OF TRAINS EACH WAY Saved	YEARLY SAVING EFFECTED	COST OF ASSISTANCE IN OPERATION PROPOSED Doubling	COST OF ASSISTANCE IN OPERATION PROPOSED Assistant Engines	COST OF ASSISTANCE IN OPERATION PROPOSED Turn around Trains	COST OF ASSISTANCE IN OPERATION PROPOSED Total	COST OF ASSISTANCE IN OPERATION PRESENT Total	Yearly saving due to decreased number of Locomotives required.	Increase + Decrease − in Operating due to Distance Rise & Fall Curvature	YEARLY SAVING IN OPERATING EXPENSES Amount	YEARLY SAVING IN OPERATING EXPENSES Capitalized Value at.....per cent	COST OF REVISIONS. TOTAL	COST OF REVISIONS. DISTRIBUTION Maintenance	COST OF REVISIONS. DISTRIBUTION Capital Improvements	COST OF REVISIONS. DISTRIBUTION Capital Grade Reductions.	Yearly Saving in per cent Cost Grade Reduct.	REMARKS.
		PER CENT		PER CENT	PER CENT	EQUIVALENT GROSS TONS						DOLLARS	DOLLARS	DOLLARS	DOLLARS	DOLLARS	DOLLARS	DOLLARS	DOLLARS	DOLLARS	DOLLARS	DOLLARS	DOLLARS	DOLLARS	DOLLARS	PER CENT	

CANADIAN PACIFIC RAILWAY

PROPOSITION..............

STATEMENT OF THROUGH TRAFFIC SHOWING OPERATING VALUE OF REDUCING GRADES TO........E.B.......W.B. RATING INCREASED TO........E.B. .... W.B.

..................................DIVISION.

from...to.. ....Miles

....SECTION OR BRANCH.

MONTH		DIRECTION	LOCOMOTIVE MILES				Tons per mile per 100% Locomotive Capacity.	Locomotive Power per cent.	THROUGH FREIGHT TRAFFIC		Weight of Train in Equiv. Gross Tons per Mile	Per Cent of Loading to Ruling Rating	Present Number of Trains	NUMBER OF TRAINS REQUIRED USING ....% LOCO. ON NEW GRADES loaded ......light Load ......E. ....W.		Number of Trains saved one way.	SAVING EFFECTED IN OPERATING Grades Reduced to........E.B.........W.B. Rating Increased to.........E.B.........W.B. Trains loaded ....light				COST OF ASSISTANCE IN OPERATION														TOTAL PRESENT	Yearly Saving due to decreased Number of Locomotives Required	OPERATING VALUE + or - DUE TO CHANGE IN			NET SAVING IN OPERATING		REMARKS
																					PROPOSED																			Trains Nos .... running daily.
																					DOUBLING				ASSISTANT ENGINES					TURN AROUND TRAINS				TOTAL								
from 190	to 190		Train Miles.	Light Running.	Doubling & Assisting	Total			Equivalent Gross Ton Miles.	Equivalent Gross Tons				Part trains	Full trains		Trains Saved	Miles	Cost per mile	Amount Saved	Trains	Miles	Cost per Mile	Total Cost	Trains	Miles	Cost per mile	Total Cost	Flat rate Cost	Trains	Miles	Cost per mile	Total Cost				Distance	Rise % Fall	Curvature	Total	Capitalized at.......per cent	
Totals																																									