#28 RETURN TO …

CANADIAN NATIONAL RAILWAYS

TELEGRAPH & TELEPHONE DEPARTMENT

F7W-9.2

SPECIFICATION FOR THE INSTALLATION AND MAINTENANCE OF GRAVITY BATTERIES

Montreal,
March 1st, 1928.

(1) GENERAL

This specification is intended to serve as technical instructions on the installation and maintenance of gravity batteries, and is issued for the guidance of battery attendants and others who are responsible for the good working of such batteries.

(2) DESCRIPTION

Gravity batteries have long been used for working telegraph and other closed circuits requiring a steady current. The use of gravity batteries for supplying current for main lines and local circuits, will be continued wherever no other suitable source of direct current is available. In determining whether any type of battery cell is suitable for working circuits requiring a steady continuous current, telegraph engineers have always considered the following points of special importance:-

Cancelled

(a) The Electromotive Force (or E.M.F.) should be high and constant: that is to say, it should remain unchanged throughout the entire life of the battery under all conditions of service.

(b) The Internal Resistance should be low and constant.

(c) It should be free from Polarization.

(d) There should be but little, if any, Local Action between the elements composing the cell, whether the latter is on open or on closed circuit.

(e) The first cost of installation, and the subsequent maintenance costs for efficient upkeep of the battery should be low.

(f) The materials employed should be easy to handle, without risk to the battery attendant.

(2) DESCRIPTION (Cont'd)

(g) Whether working or at rest, the battery should not give off offensive or unhealthy fumes.

(h) Finally, the battery should not require very frequent attention or renewal of material.

(3) The gravity cell satisfies the above conditions so well, especially in respect to the value and constancy of its E.M.F. and of its internal resistance, that it is admirably adapted for working telegraph circuits. It is remarkably free from polarization. Local action cannot, it is true, be entirely prevented in the gravity cell owing to the natural tendency of the solutions to mix. Local action is, however, reduced to a harmless minimum by employing commercially pure zinc immersed in a solution of zinc sulphate, the latter being non-active towards zinc. Local action is also reduced by care in preparing the cells, and by not shaking them or agitating the solutions after the cells have been made up. The special design of the zinc, whereby it can be readily removed at any time for cleaning, greatly facilitates the removal of the spongy deposit of copper which forms on the zinc element as the result of local action.

(4) The gravity cell consists of a glass jar containing a copper and a zinc electrode, each of which is immersed in a solution of its own sulphate, as shown on Drawing, Page 19.

(5) The sulphate solutions are kept separate by reason of their difference in specific gravity, assisted by the electro-chemical action of the cell: the denser, nearly saturated sulphate of copper solution occupies the bottom of the jar, while the lighter, dilute solution of zinc sulphate of lower specific gravity floats on top. In Figure 1 (a) of the above mentioned drawing is shown a glass jar with the copper and zinc electrodes in position, a view of a complete cell fully assembled being shown in the adjoining Figure 1 (b).

(6) The cylindrical glass jar, of 6" inside and 6-1/2" outside diameter, stands 8" high overall.

(7) In the bottom of the glass jar is placed the copper, or negative element, consisting of three leaves of #32 B.& S. gauge sheet copper, each leaf being 6" long and 2" deep. The three leaves are fastened together at the centre by means of a copper rivet. To one end of the middle lead is riveted a #14 B.& S. gauge copper leading wire or stem, which is 15" long overall. This leading wire is covered with guttapercha insulation for about 12", i.e. almost throughout its length. It is bare for about an inch at the lower end where it is riveted to the copper element, and it is also laid bare for about two inches at the upper end, for connecting purposes.

(8) It is most important that copper rivets only should be used for fastening the copper leaves, and for securing connection between the leading wire and the centre leaf. The reason for this is, that the use of a rivet of any other metal, or of solder, in contact with the copper plate, would result in the formation of a miniature galvanic cell producing local action to the detriment of the general working of the battery. Such local action, by its corrosive effects, would in a short time destroy the connection between the stem and the middle leaf, and cause either a complete open or a fault offering very high resistance.

(9) It is also highly important that the guttapercha covering should completely enclose and protect the stem, from the riveted end as far as the bare end. The guttapercha should be tough, but pliable enough to bend without cracking or other injury. It should be homogeneous and free from cracks or blowholes. Its principal function being to afford mechanical separation of the leading wire from the solutions except at the riveted end, it should closely adhere to the copper wire. Otherwise it might act as a capillary tube. In this way it would permit the copper sulphate solution to creep along its interior and exude at the top, producing corrosion of the terminal. Or, the copper sulphate solution might work its way from the bottom to the top of the jar, thereby coming directly in contact with the zinc element and causing heavy local action. In the same way, the copper sulphate solution of one cell might be carried over into the zinc sulphate solution of the next cell. The occurrence of the latter two troubles would finally result in the zinc being consumed to no purpose and then completely covered with metallic copper, producing in effect a copper instead of a zinc element, thereby destroying the difference of potential necessary to establish an electro-motive force with the copper element itself, and stopping the main action of the cell. The effect of a crack or a blowhole occurring in the guttapercha above the lower level of the zinc sulphate solution would be to cause local action where the copper stem was exposed, and the wire would be eaten through in a short time. The reason for selecting guttapercha for covering the stem, in preference to rubber, is because the former retains its pliability and adhesiveness, and lasts for a long time without cracking or perishing, when immersed in aqueous solutions. Rubber on the other hand hardens and cracks, and soon perishes when so immersed.

(10) The zinc element is a casting of the crowfoot type, and weighs about 3-1/4 lbs. It has a stout zinc leg, shaped like an inverted "J" which serves as a hanger or hook by which it can be suspended on the side of the glass jar. When thus placed in position, the "crowfoot" spreads out horizontally with its top surfaces about 1-3/4 inches below the top of the glass jar. The top of the hanger is fitted with a brass binding post and screw for connecting purposes. The zinc should be as pure as possible, and should contain at least 98.90 per cent by weight of chemically pure zinc.

(11) The sulphate of copper or bluestone used in making up gravity cells must be in medium sized crystals between the size of a hazel-nut and a walnut. It should be clean, free from dirt and green oxide of copper or other impurities. About 3 lbs. of the crystals should be used per cell, this quantity when properly packed between the leaves of the copper element being sufficient to fill the bottom of the jar to the level of the top of the copper leaves. Powdered sulphate of copper should not be used in this type of cell.

(12) The zinc sulphate solution being formed in the top of the jar in the ordinary electro-chemical action of the cell, it is not necessary to carry a stock of crystals of zinc sulphate. Some of the zinc sulphate solution is syphoned off, from time to time, as explained later on, when the specific gravity is becoming high, and a suitable quantity of this solution may be stored in glass jars for use in preparing cells for immediate use. The zinc sulphate solution so obtained should always be purified from any trace of sulphate of copper with which it may be mixed, by leaving in it some pieces of clean old scrap crowfoot zinc. Any trace of sulphate of copper present will be transformed into zinc sulphate, the resulting copper being deposited on the scraps of zinc.

(13) The water used in gravity cells is a very important factor. Permanently hard, or brackish water is the least suitable for battery use, and should be avoided as far as possible. Water of temporary hardness may be made suitable by boiling. Clean river water which has been first allowed to stand, then syphoned off or poured out so as to free it from its muddy deposit, will be found very suitable. Rain water is the best of all natural waters. The selection of water is often, however, not a matter of much choice. In places where the water is very hard or brackish, rain water may be stored in wooden barrels, if practicable; but some battery or kerosene oil should be poured on top so as to form a complete film, to prevent the stored rain water becoming a mosquito hatchery. The film of oil will also prevent evaporation of the water.

(14) Battery oil is a cheap grade of crude mineral oil used for pouring on the solution, on which it floats so as to form a film about 1/8 inch thick. The film of oil prevents evaporation of the solution.

(15) CHEMICAL ACTION

The ordinary chemical action of the cell may be simply expressed as follows:- Zinc is consumed, sulphate of zinc is formed, sulphate of copper is decomposed, and copper resulting from the decomposition of the copper sulphate is deposited on the leaves of the copper electrode.

(16) The above action is represented in chemical formulae, thus:-

(16) (Continued)

(a) Before action -

Zn	+	$Cu\ SO_4$	+	Cu	=	— =
Zinc (one part)		Sulphate of Copper		Copper (one part)		—

(b) After action -

$Zn\ SO_4$	+	$2\ Cu$
Sulphate of Zinc		Copper (two parts)

(17) According as the zinc is eaten away, the copper element increases in weight, owing to the deposit of copper. The sulphate of copper crystals gradually disappear as they part with their copper, the "sulphate" constituent uniting with the zinc and forming sulphate of zinc. The latter appears in solution in the upper part of the jar as a clear colorless liquid. In course of time this solution will increase in density up to the point of saturation, after which, if some of the solution is not removed and replenished with plain water, it will not be able to hold any more zinc sulphate. Should this be permitted to happen, the excess of zinc sulphate will crystalize out, and by a peculiar creeping process spread itself over the top and outside of the jar, and finally along the battery racks to the floor. In this way the whole or part of the battery may be short-circuited to ground where the creeping occurs. Such a condition must not be permitted to exist. It can only arise through gross neglect, and can be prevented by ordinary care.

(18) All of the copper given up by the sulphate of copper does not adhere to the copper leaves. Some of it forms on the zinc as a brownish colored mud of spongy appearance. This happens from local action, caused by some of the sulphate of copper, in spite of its greater weight or higher specific gravity, rising by diffusion into the upper part of the jar. Coming there into direct touch with the zinc, these traces of copper sulphate attack the latter directly, and the resulting copper which is set free, settles on the zinc.

(19) This local action is a waste of energy; the zinc and the sulphate of copper consumed thereby generating no useful electrical current. It follows, therefore, that not only has the sulphate of copper to be replenished and the zinc renewed in course of time, but the zinc itself will need frequent cleaning by having the mud deposit removed.

(20) The ordinary chemical action of the cell results in the maintenance of a difference of potential between the zinc, or positive element, and the copper, or negative element, within the cell. In virtue of this difference of potential, electrical current flows from the zinc to the copper inside the solutions. Outside the jar, the current passes from the copper, or positive terminal, through the external circuit, and back again to the zinc, or negative terminal.

(21) The Electromotive Force of the gravity cell is 1.07 volts. The Internal Resistance is from 2 ohms to 3 ohms per cell.

(22) a. The useful life of a gravity cell as employed in telegraph work, reckoned from the time the cell has been made up new until the first renewal of the zinc is required should be at least 200 ampere-hours.

b. The following table shows the initial quantity of material required for setting up a cell, and the average total quantity of such material used per cell per annum:-

Kind of Cell	Material	Required for Initial Charge	Quantity Required per Annum
Main Line	Zinc	1	2
	Copper	1	1
	Sulphate of Copper	3 lbs.	8 lbs.
Local	Zinc	1	2-1/2
	Copper	1	1
	Sulphate of Copper	3 lbs.	10 lbs.

(23) DUPLEX & QUADRUPLEX WORKING

At stations where the main line currents of quadruplex or bridge duplex circuits are supplied by gravity batteries, a separate battery should be assigned to each duplex or quadruplex set. The number of cells required for such batteries, under ordinary conditions, is shown in the following table:-

(23) DUPLEX & QUADRUPLEX WORKING (Cont'd)

Length of Line Wire in Miles	Number of Gravity Cells Required for Each Bridge Duplex Set		Number of Gravity Cells Required for Each Quadruplex Set	
	Where line wire is #9 B.& S.Gauge Copper	Where line wire is #8 B.W. Gauge Iron	Where line wire is #9 B.& S.Gauge Copper	Where line wire is #8 B.W. Gauge Iron
50	20	27	80	110
75	24	35	89	133
100	28	43	98	156
125	32	54	108	180
150	36	65	118	204
175	40	77	129	230
200	44	90	140	257
225	48	104	156	290
250	52	119	173	330
275	58	134	190	
300	64	150	208	
325	70	166	227	
350	77	183	247	
375	83	203		
400	90	224		
425	97	246		
450	104	270		
475	112	298		
500	120	330		
525	128			
550	137			
575	148			
600	160			

(24) With duplex sets of the differential type, it is not necessary to provide a separate battery for each set in stations having two or more similar circuits. In such cases separate banks of gravity cells may be provided for the two potentials. The number of cells in each of the two banks shall be the same as that given in the above table for the separate battery required for the circuit of greatest length and resistance. Each pair of banked batteries may be used to operate two or three circuits; four circuits may often be satisfactorily operated from the same banks if none of the lines exceed 200 miles in length.

(25) SINGLE MORSE WORKING

Where gravity batteries are used to supply the main line currents for a number of single Morse circuits, it is not necessary, in most cases, to assign a separate battery to each circuit of that class.

(25) SINGLE MORSE WORKING (Cont'd)

The number of such circuits which can be worked from one battery is very limited, however, because of the internal resistance of the cells.

(26) The greater the number of lines operated from a battery of gravity cells, the lower will be the working margin of each line. This is because the voltage drop in the internal resistance of the battery, and hence the effective voltage on the line depends on the number of lines which are simultaneously closed. When all the lines are closed, the marking current in each of them will be at its minimum value. When all the lines are open except one, the marking current in the closed line will be at its maximum value. If too many lines are being worked from one battery, the difference between these minimum and maximum marking current values on any one of the lines may be greater, in wet weather, than the difference, in the spacing and marking current values caused by the opening and closing of the key at a distant station. The false signals resulting from such a condition would, of course, make the lines unworkable.

(27) Drawings Pages 20, 21, 22, 23, 24 and 25 show the number of gravity cells necessary to efficiently operate lines of various resistances and lengths, when 1, 2, 3 and 4 lines are to be worked from the same battery. These curves are based upon the gravity battery having a maximum internal resistance of 3 ohms per cell, and the line wires having a minimum insulation resistance of 0.4 megohm per mile.

(28) The method of using these curves may best be understood by studying the following examples-

Example #1. A 200-mile line, of #8 B.W. gauge iron wire, has sixteen 150-ohm Morse relays in circuit. The total resistance of the line wire and relays is found, either by measurement or calculation, to be 5000 ohms. It is required to find the number of gravity cells necessary at each terminal to efficiently operate this circuit. Referring to Drawing Page 20, the intersection of the horizontal line marked "5000" and the inclined straight line marked "1 line", is on the vertical line corresponding to 104 cells. To determine whether or not the circuit is workable, the horizontal line marked "5000" is now followed further to the right until it intersects the limiting length curve marked "1 line". This intersection is on the vertical line corresponding to 370 miles, thus indicating that the 200 mile line under consideration will operate satisfactorily. It will therefore be safe to provide a gravity battery of 104 cells at each terminal of this circuit.

(28)(Continued)

Example #2. Suppose, however, it is desired to work more than one circuit from each of the terminal batteries, but that none of the circuits exceed in length and resistance the circuit mentioned in Example #1. By again following the horizontal line marked "5000", it is found to intersect the vertical line marked "200 miles" at a point between the "2-lines" and "3-lines" limiting length curves. This indicates that two such circuits may be satisfactorily operated from one battery at each terminal. The number of cells required for each terminal battery under the changed conditions is found by retracing the horizontal line marked "5000" to its intersection with the inclined straight line marked "2 lines". The intersection is on the vertical line corresponding to 120 cells.

(29) In both the above examples, Drawing Page 20 has been referred to because gravity battery was assumed to be used at each terminal in the case given, and the 150-ohm relays mentioned normally require an operating current of about 40 milliamperes. For other conditions, the same methods of using the curves are applied to other drawings. For example, if the conditions stated in Examples #1 and #2 had been varied only by assuming the distant terminal of each circuit to be operated from generators or storage battery instead of gravity cells, Drawing Page 21 would have been used instead of Drawing Page 20. If, instead of gravity battery, generators or storage battery, the distant terminal were connected to ground, the curves on Drawing Page 22 would be referred to.

(30) As stated above, Drawings Pages 20, 21 and 22 are to be used for the three arrangements of current supply on circuits employing relays which normally require an operating current of 40 milliamperes. The relay now generally used for such circuits is the 150-ohm Morse Relay, 4-B, and in Examples #1 and #2 it was assumed that this style of instrument was employed. A new relay, known as the 100-ohm Morse Relay 4-C, is now being introduced, which operates quite as satisfactorily on a current of 40 milliamperes as the 150-ohm Morse Relay 4-B. Great advantages will result, in many cases, from the use of the 100-ohm relays on circuits operated with gravity batteries. For instance, in Example #1 the reduction of 50-ohms in the resistance of each of the sixteen relays would make the total resistance of the circuit 4200 instead of 5000 ohms. By reference to Drawing Page 20, it will be seen that this would reduce the number of gravity cells required at each terminal from 104 to 92. What might prove a still greater advantage in some cases is illustrated by applying the lower resistance relays to Example #2. In this case, the curves show that the reduced resistance will permit three lines to be operated from the same gravity battery of 120 cells at each terminal.

(31) Drawings Pages 23, 24 and 25 should be used in determining the number of cells required and the limiting lengths of lines equipped with relays having a normal operating current of 65 milliamperes. The relays used on such circuits are the 35-ohm Morse Relays, 4-B and 25-ohm Morse Relays, 4-C. The use of 25-ohm relays instead of 35-ohm relays has similar advantages to those described for 100-ohm relays in place of 150-ohm instruments.

(32) When a number of lines are fed from the same battery it is preferable that all should be of the same resistance.

(33) When several banks of battery are necessary, each bank to supply a group of lines, the lines should be so chosen that each battery supplied current to lines of approximately equal resistance.

(34) When the resistance of any of the lines to be fed from one battery do not vary more than 30% from that of the highest resistance line of the group, the lines should be approximately equalized by either or both of the following methods:

(a) Substitution of Morse Relays 4-C for Morse Relays 4-B in the higher resistance circuits.

(b) Insertion of non-inductive resistances in the lower resistance circuits. In the case of a line having current supplied to it from both terminals, the value of the non-inductive resistance should not exceed 1000 ohms, and it should be located as near the centre of the circuit as practicable. In the case of a line having current supplied from one terminal, the value of the non-inductive resistance should not exceed 500 ohms, and it should be located at the grounded terminal of the circuit.

(35) When the resistance of the lines to be fed from one battery vary to such an extent that equalization is impracticable the lower resistance lines may be connected to various intermediate points in the battery. The number of cells between the tap connections and the ground should be approximately proportional to the resistances of the lines. This method, however, has the disadvantage that some of the cells in the battery require more frequent renewal than others.

INSTALLATION

(36) Where a large number of gravity cells is required, the batteries should be installed on battery racks built locally of well-seasoned suitable timber. The racks should be constructed along the general lines indicated on Drawing Page 26.

(37) The height, length and number of shelves will depend on local conditions, number of cells and the space available.

(38) Where two rows of cells must be accommodated on each shelf, the shelves should be at least eighteen inches (18") wide. In this case the rack should be accessible from both sides.

(39) Where a rack has to be built against a wall and only one row of cells is to be installed on each shelf the shelves should be 9" (nine inches) wide.

(40) The shelves should be built of substantial strips spaced about one-half inch apart. Shelves should be so placed as to provide twelve inches (12") clear vertical space between them. Where space permits, the lowest shelf should be eighteen inches (18") above the floor.

(41) It is desirable that racks should not be higher than seven feet (7'). This height will permit of five (5) shelves, and leave the upper one easily accessible. Where, however, floor space limits make it necessary, higher racks may be built; but in that case, suitable means should be provided for reaching the upper shelves.

(42) Racks shall be painted with two coats of asphaltum paint, or thoroughly oiled.

(43) Where the number of cells required is small, the batteries may be installed on racks or in locally built cabinets, as may be most convenient. It should be noted, however, that the necessary maintenance work is less likely to be overlooked if the cells are in plain view at all times.

(44) Before setting up the cells, the jars should be thoroughly cleaned and dried. Each copper should then be placed unfolded in the bottom of its jar, and the stem brought straight up to overhang the top of the jar. About three pounds of copper sulphate in crystals should then be packed between and around the leaves of the copper electrode. Powdered sulphate of copper should never be used as it cakes in the bottom of the cell.

(45) The zinc electrode should now be hung in position and the jar filled with water to within about 1-1/4" from the top, so as to cover the "crowfoot" of the zinc.

(46) A layer of battery oil about 1/8" deep should be poured over the solution.

(47) A cell prepared in this manner should be short circuited by clamping the bare end of the copper stem to the zinc binding point, and then allowed to stand for a period of 24 to 36 hours. By this time sufficient zinc sulphate solution will have formed, and the cell will

(47) (Continued)

be ready for use. When this stage has arrived the blue line marking the separation between the deep blue copper sulphate solution and the clear zinc sulphate solution will stand midway between the top of the copper leaves and the lower part of the zinc element.

(48) When cells are required for immediate use, however, the result of this preliminary action in forming sufficient zinc sulphate, may be anticipated by using some of the zinc sulphate solution taken from older cells in use. It is, therefore, a good plan to save some of the clear zinc sulphate solution removed from old working cells which are in good condition and to store same for emergency purposes. As already stated, old solution of this kind should be treated by leaving in it some pieces of scrap zinc. The latter will purify the solution by converting any traces of copper sulphate solution present into sulphate of zinc.

(49) When obtaining zinc sulphate from working cells actually in use, only the clear solution in the upper part of the jars should be taken. The solution should be carefully drawn off; a syringe or a rubber syphon being used for the purpose. Clean, fresh water should then be added to the cells to replace the removed solution and restore the liquid to the proper height. In these operations the utmost care should be taken to avoid splashing or undue agitation of the blue solution in the bottoms of the jars.

(50) As soon as sufficient zinc sulphate solution is present in the newly prepared cells, they may be placed upon the rack and connected up. Cells should not be allowed to touch each other on the racks. A space of at least one inch (1") should be allowed between cells. Care should be taken to see that the ends of connecting stems and also the binding posts on the zincs are beight and clean, and that all connections are properly secure. Battery connectors should be used to connect the end cells to the power leads. Special care should also be taken, when setting up the cells, not to spill any solution. The tops and outsides of the jars and the shelving should be wiped dry. Spilled solution, or wet jars or shelving, will start "creeping" or precipitation of white crystals of zinc sulphate. The presence of these crystals on the jars and shelving may cause grounding or short circuiting of the whole or part of the battery. A copy of Form Pages 17 and 18, "Care of Gravity Batteries", being an appendix to this specification, shall be displayed prominently on each gravity battery cabinet and in every battery room.

MAINTENANCE

(51) In handling gravity battery coppers, care should be taken not to injure the guttapercha insulation on the stems. Coppers should not be kept in sunlight or in a very hot or dry place, otherwise the stem

(51) (Continued)

insulation will dry up and crack. It is, in fact, best especially in very dry climates, to keep coppers that are not in use under water with their stems fully immersed. If so stored, the guttapercha will last for years, without cracking or deteriorating.

(52) As the copper elements are not consumed by the action of the battery, they should be kept in use as long as possible. No copper may be taken out of service until either the stem insulation shows signs of perishing, or until the deposit of electrolytic copper formed on it by the current becomes inconveniently large, or so big that further retention of the element in service would be likely to injure the jar when dismantling. In general, coppers should last about one year.

(53) A gravity battery zinc will last about six months in a main line cell, and from four to five months in a local cell.

(54) About eight (8) pounds of copper sulphate per annum is consumed in a main line cell, and about ten (10) pounds per annum in a local cell. The consumption will, however, be considerably less in cells that are not heavily worked.

(55) The most suitable temperature for a battery-room is somewhat about sixty (60) degrees Fahrenheit. If the room is colder than this, the internal resistance of the battery will rise rapidly with decrease of temperature. On the other hand, too high a temperature will cause rapid evaporation.

(56) The general condition of working cells may be judged by the colors of the solutions, and by the position of the "Blue Line" dividing them. The sulphate of copper solution in the lower half of the cell should be a clear deep blue color. When it becomes a muddy brown, the cell is deteriorating and should be cleaned.

(57) The zinc sulphate solution should be clear and colorless. The cell is in its best condition when the density of this solution, as determined with a hydrometer, is about twenty (20) degrees Baume. If the density rises to twenty-five (25) degrees, the zinc sulphate will be precipitated on the edge of the jar and cause creeping. At the first indication of this, sufficient solution should be drawn off and replaced with water until the density drops to twenty (20) degrees. If the density of the solution falls to five (5) degrees, the cell will need to be short circuited so as to form more zinc sulphate, or some spare zinc sulphate solution from old cells should be added until the density rises to twenty (20) degrees.

(58) When a cell is in good condition the solution will be divided by a distinct blue line about midway between the two electrodes. When this line rises very close to the zinc, the cell should be short circuited until the blue line has fallen to its proper level.

(59) When the blue line falls, but there still rem ins a good supply of unconsumed copper sulphate crystals in the bottom, some of the zinc sulphate should be syphoned off the top and water added. A battery syringe, or a rubber hose syphon should be used for this purpose.

(60) The zinc sulphate should always be high enough to cover the top of the crowfoot zinc. To compensate for water lost by evaporation, a little water should be added from time to time, to keep the solution at the proper level. A strong jet of water should never be used as this tends to mix the solutions and injure the cell.

(61) All connections should be frequently examined to see that they are clean and tight. Many gravity battery troubles are due to dirty or loose connections.

(62) If a jar becomes cracked or broken, it should be promptly removed, and the cabinet or rack shelving should be thoroughly cleaned to remove all trace of spilled solution or crystals, and finally dried.

(63) There are two processes of cleaning required in connection with the battery. The first is of a frequent periodic nature, involving the temporary withdrawal of the zinc only. The necessity for cleaning the zinc arises principally from the presence of copper deposit which is being formed all the time the battery is in use. Before attempting to remove the zincs, the cells should be taken off the rack, care being taken not to unduly shake the jar causing the solutions to mix. The zincs should then be carefully scraped, and freed from all deposit. The deposit is usually of a dark brown color and consists largely of electrolytic copper in a fine state of division. It is sometimes called "mud" deposit. It should not be thrown away, but kept in a suitable receptacle for future disposal. Its removal from the zincs should be effected promptly while it is still wet, otherwise, if allowed to dry, it will harden and be very difficult to remove. As soon as each zinc has been cleaned, it should be put back in the cell and the latter once more connected up in the battery series.

(64) The zincs require cleaning about every three weeks in the case of local cells, and less frequently in the case of line cells. The exact periods will depend upon the amount of work the battery is called upon to do, and should be ascertained by the battery attendant by a careful examination of each cell once a week. Those responsible for cleaning the zincs should not evade their duty, as sometimes has been done, by removing and throwing out of service dirty zincs which are still good, and replacing them with new zincs.

(65) The second cleaning process is more extensive, and consists of general overhauling. As in the case previously described, the cells must be taken off the racks before removal of any of the elements or solutions is attempted. The zincs are removed first. They should be immediately placed in water and kept there to prevent the mud deposit hardening until they can be cleaned.

(66) The clean part of the zinc sulphate solution may be saved. It can be used over again. A battery syringe or syphon hose should be used for drawing off this solution. In using a syphon hose, first fill it with water, close both ends with the fingers, putting one end in the battery solution, holding the other end below the level of the jar. On opening both ends of the hose, the water will flow away, followed by the solution. When sufficient clear solution has been drawn off close the hose again at both ends before withdrawing it from the cell.

(67) The remainder of the solution in the jar may be drained off and, unless it is a clear blue color, should be thrown away. Any clean blue solution or crystals of sulphate of copper remaining should be saved. They can be used in making up new cells. The mud deposit or any loose metallic copper in the bottom of the jars should be put away, each in its proper receptacle, to await future disposal. If the mud deposit is caked in the bottom of the jar, it may be more easily removed, and with less risk of injury to the jar, if the latter is allowed to stand in the sun to dry out.

(68) After cleaning and drying, the jars will be ready for re-installation, the procedure to be followed being similar to that outlined under the head of "Installation".

(69) Old coppers and old pieces of zinc should be kept in separate barrels for return to the storekeeper. The other scrap material consisting mainly of mud deposit should also be kept in a separate barrel or box. When the barrels or other receptacles are full, they should be securely fastened and the Superintendent notified as to what material is ready for shipment.

(69) (Continued)

When instructions are received from the Superintendent as to shipping, each package should be plainly marked to indicate the place from which it is shipped and what it contains.

Approved:

W. G. BARBER

General Manager,
Can.Nat.Telegraphs.

Engineer of Standards.

APPENDIX

COPY OF FORM

RULES FOR THE CARE OF GRAVITY BATTERY

(1) MAINTENANCE

a. Battery Cabinets and Battery Racks must be kept thoroughly clean and dry.

b. All connections must be kept clean and tight.

c. The "blue line" dividing solutions should be kept about midway between the electrodes.

d. When the blue line falls close to the copper, draw off some of the light, upper solution(zinc sulphate) and replace it with water.

e. When the blue line rises close to the zinc, short circuit the cell until the blue line falls to the proper level.

f. The top of the solution must be kept above the zinc. Replenish with water if necessary.

(2) TO SET UP A CELL

a. Unfold the copper in the bottom of the jar, bringing the stem straight up and out at the top.

b. Put about 3 lbs. of bluestone between and about the copper leaves.

c. Hang the zinc in position.

d. Fill the jar with water above the level of the zinc.

e. Cover the solution with a 1/8" layer of Battery Oil, and wipe dry with edge and outside of the jar.

NOTE:- A cell set up as above will not reach its full strength for some time. The action may be hastened by replacing some of the water with a little clear zinc sulphate solution obtained from other cells. If this solution is not available, and the cell is not required immediately, it should be short circuited until the blue line is midway between the zinc and the copper.

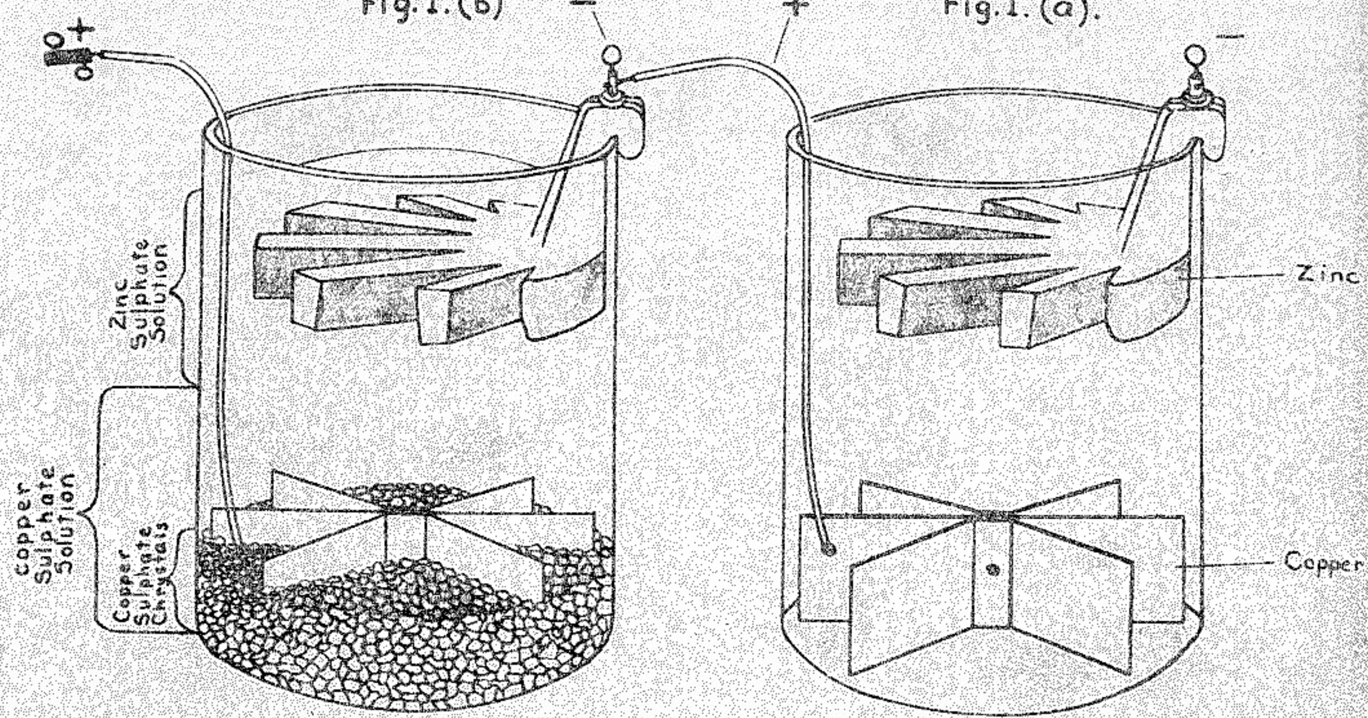
(3) TO CLEAN A CELL

a. Draw off and save the clean portion of the upper solution (zinc sulphate).

b. Carefully clean the zinc and the jar, and wash the copper.

c. Set up the cell as above, using the retained clear solution to start the action of the cell.

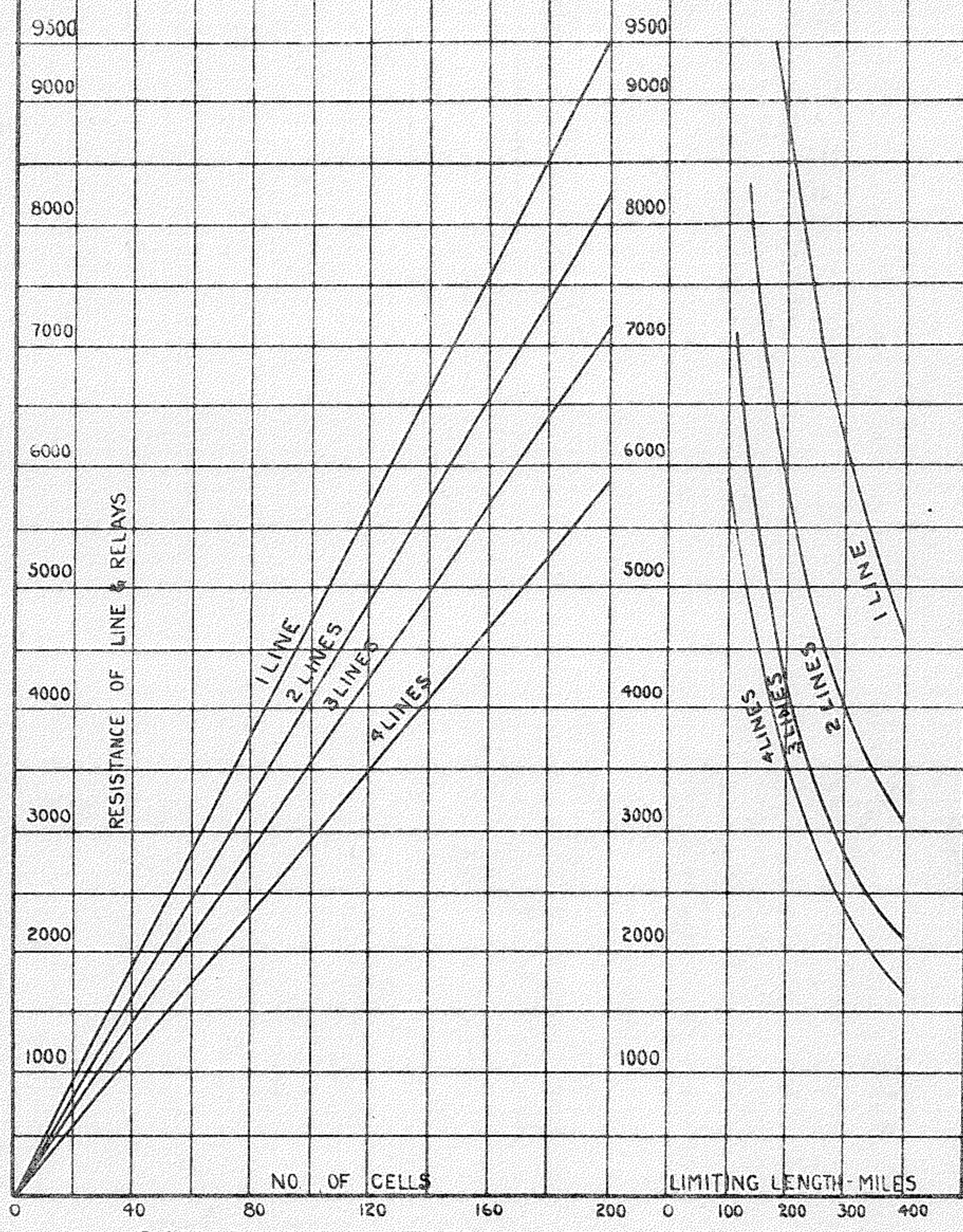
F7.W-9.2
Montreal. Mar. 1st 1928.



Cell Complete with Crystals and Solutions

Cell incomplete showing Zinc and Copper but no Crystals or Solution.

CANADIAN NATIONAL RAILWAYS
TELEGRAPH & TELEPHONE DEPARTMENT
GRAVITY BATTERY



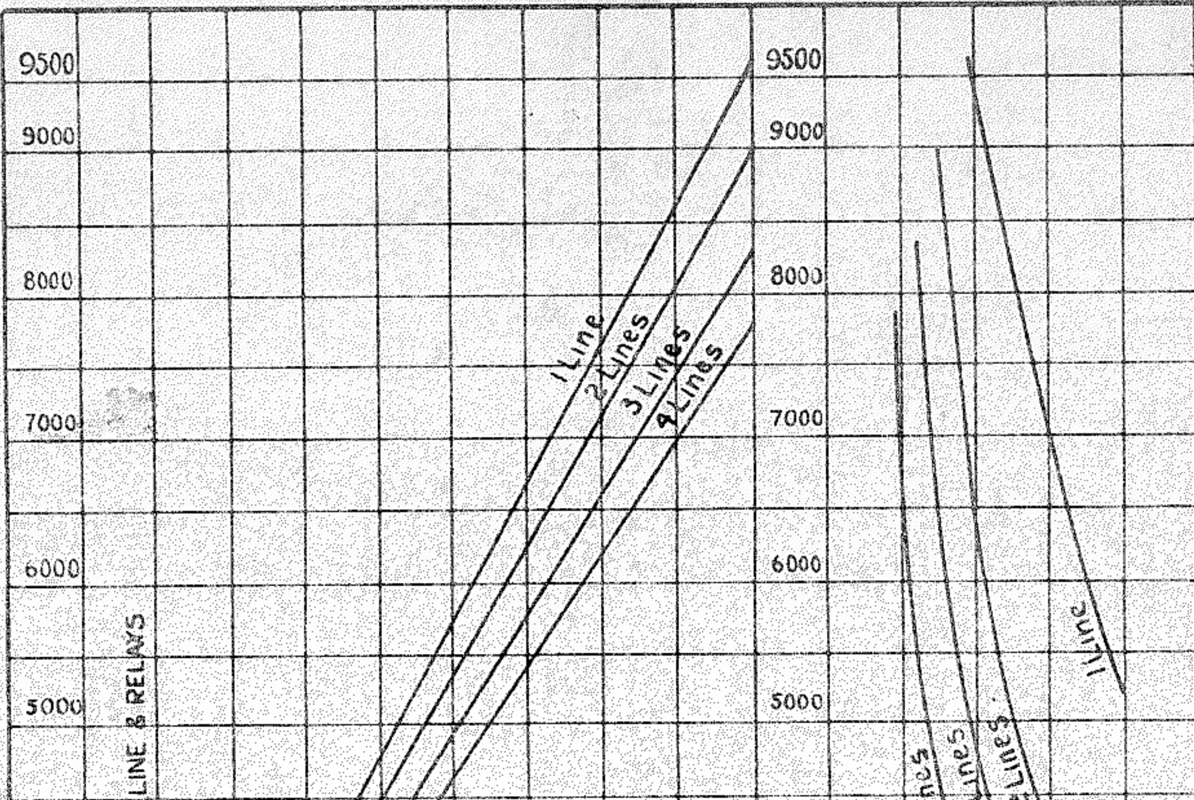
CANADIAN NATIONAL RAILWAYS

TELEGRAPH & TELEPHONE DEPARTMENT

GRAVITY BATTERY

Curves for Circuits having Gravity Battery at each end; fair weather operating current 40 Milliamperes

F7W-9.2
Montreal, Mar. [illegible] 1928



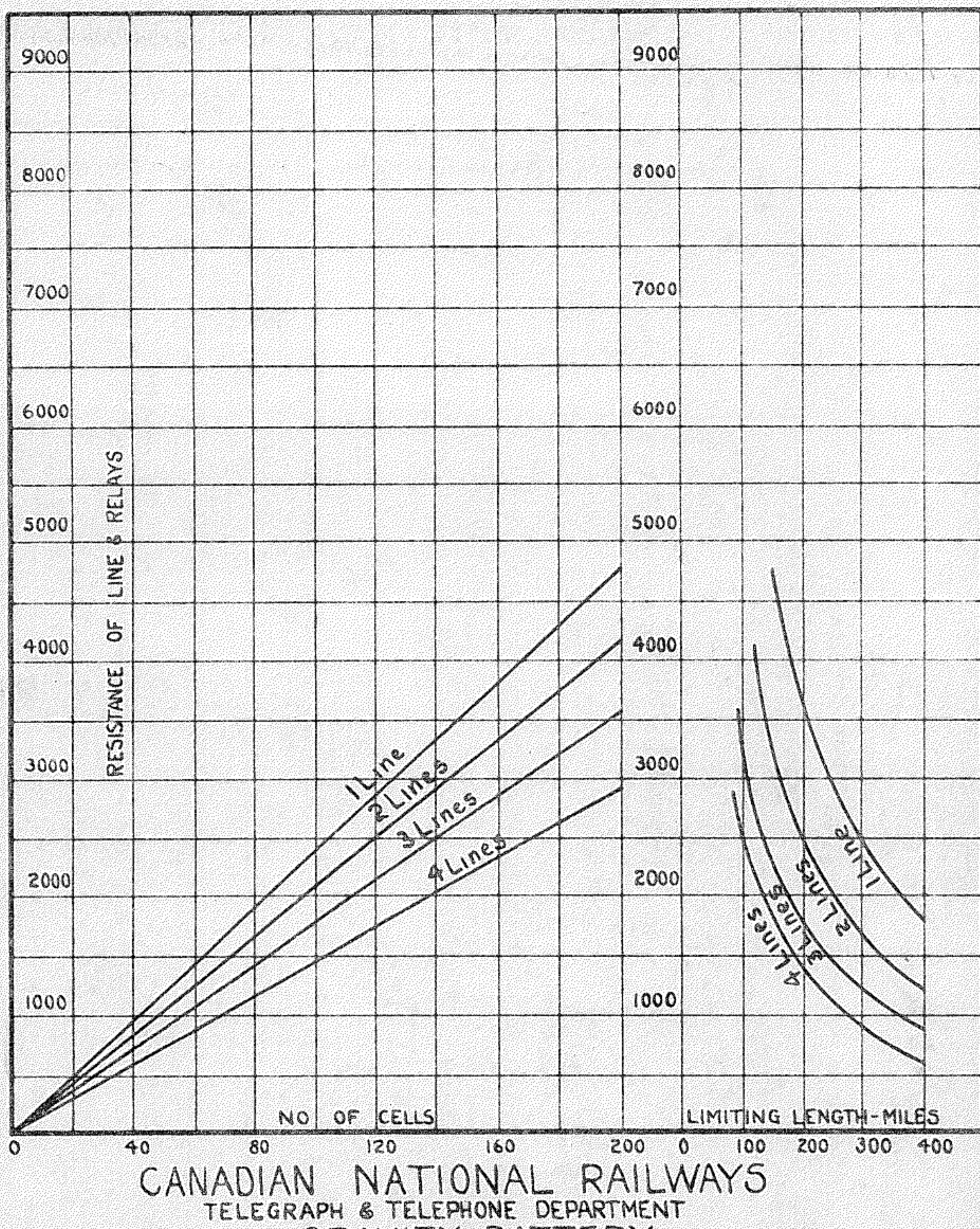
CANADIAN NATIONAL RAILWAYS

TELEGRAPH & TELEPHONE DEPARTMENT

GRAVITY BATTERY

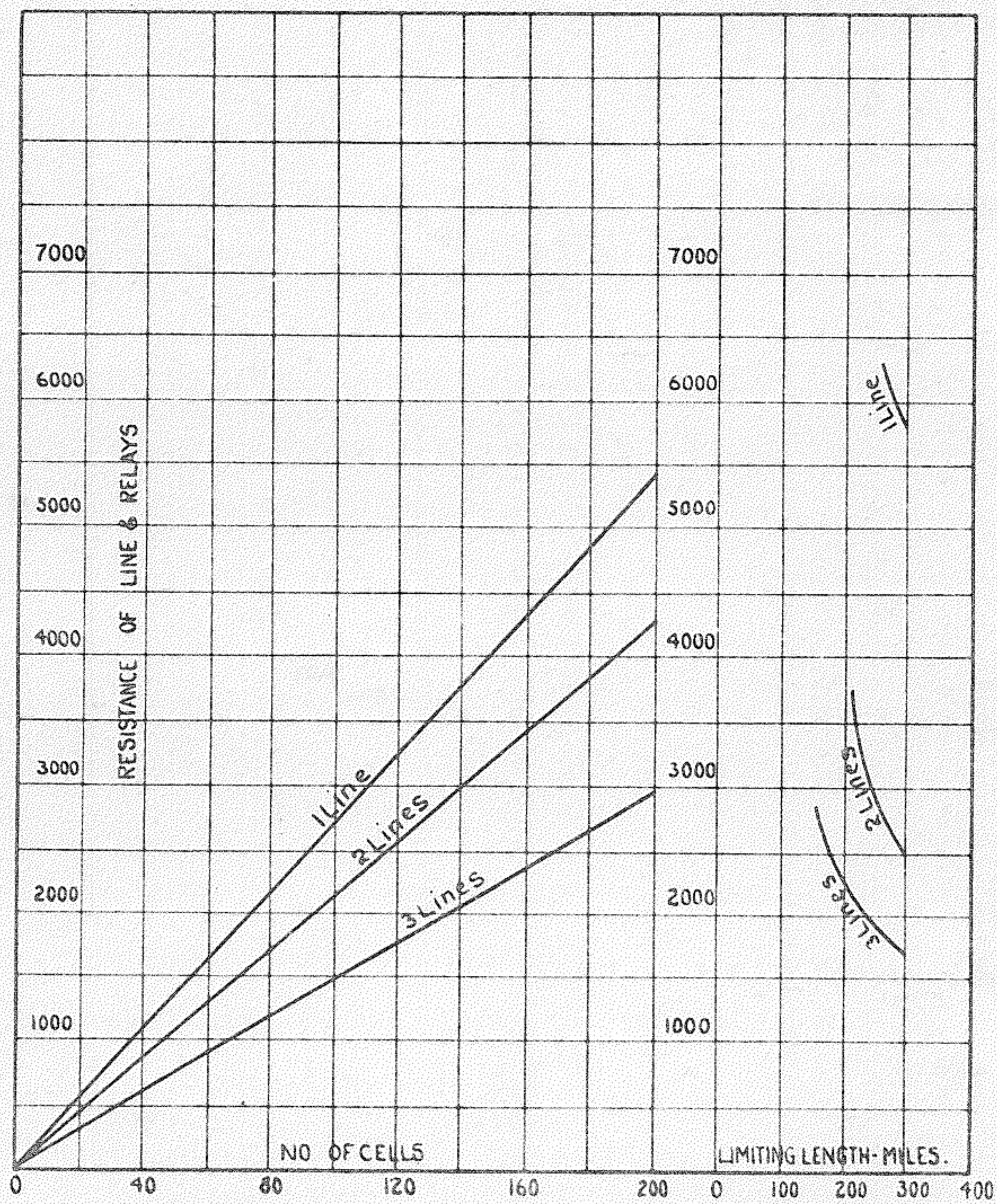
Curves for Circuits having Gravity Battery at home end and Generator or Storage Battery at distant end; fair Weather operating current 40 Milliamperes.

F7W-9.2
Montreal, Mar 1st 1928.



CANADIAN NATIONAL RAILWAYS
TELEGRAPH & TELEPHONE DEPARTMENT
GRAVITY BATTERY

Curves for Circuits having Gravity Battery at home end and Ground at distant end; fair weather operating current 40 Milliamperes.



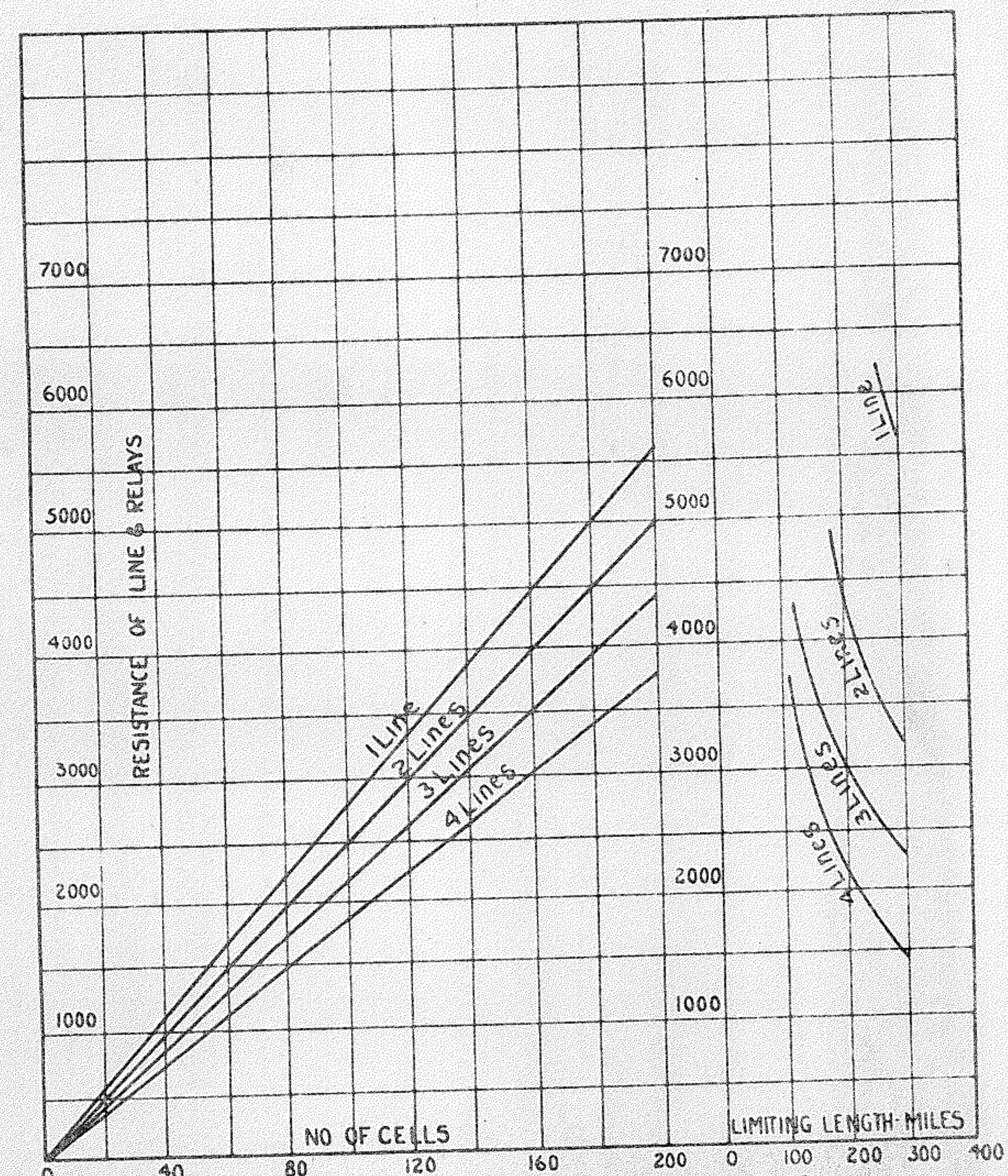
CANADIAN NATIONAL RAILWAYS

TELEGRAPH & TELEPHONE DEPARTMENT

GRAVITY BATTERY

Curves for Circuits having Gravity Battery at both ends; fair weather operating current 65 Milliamperes.

F7W-9.2
Montreal, Mar 1st 1928.

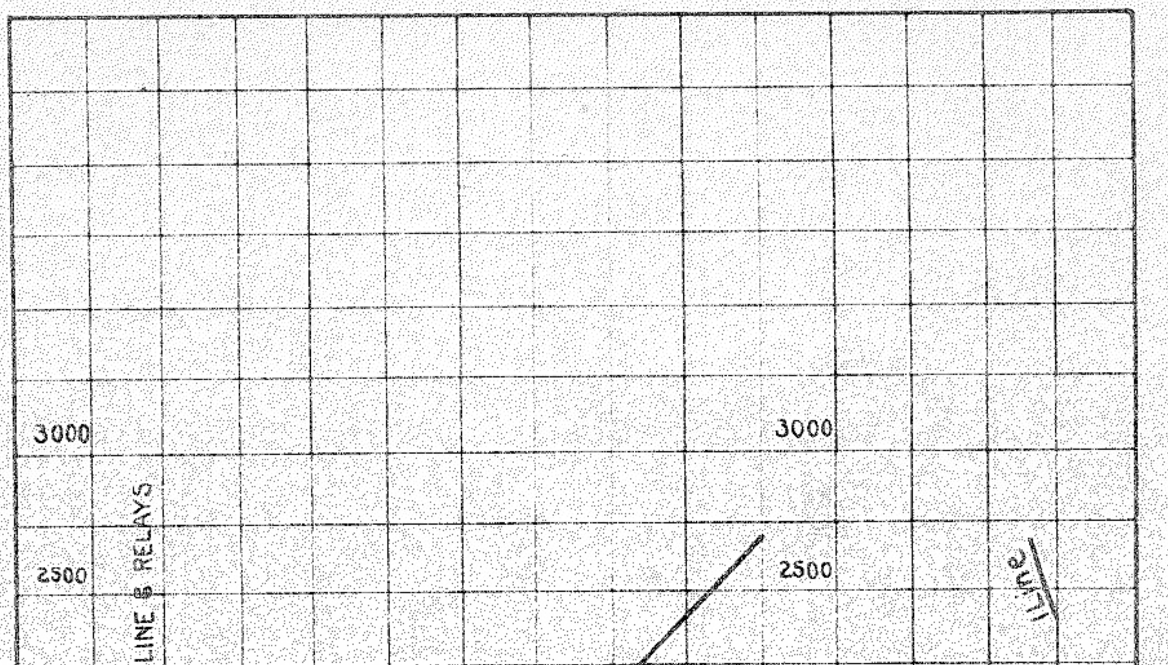


CANADIAN NATIONAL RAILWAYS

TELEGRAPH & TELEPHONE DEPARTMENT

GRAVITY BATTERY.

Curves for Circuits having Gravity Battery at home end and Generator or Storage Battery at distant end; fair weather operating current 65 Milliamperes.



CANADIAN NATIONAL RAILWAYS

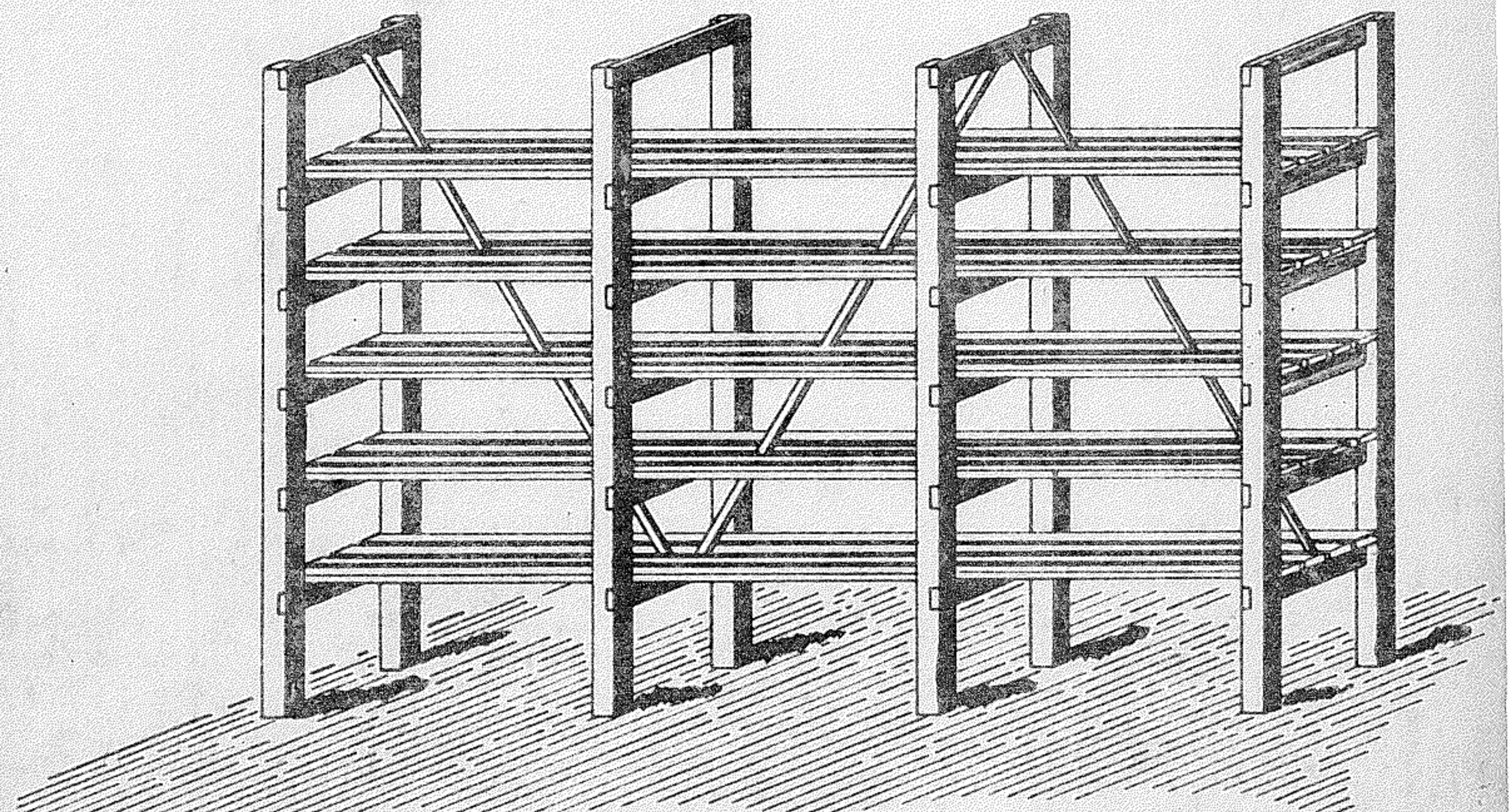
TELEGRAPH & TELEPHONE DEPARTMENT

GRAVITY BATTERY

Curves for Circuits having Gravity Battery at home end and Ground at distant end; fair weather operating current 65 Milliamperes.

F7W-9-2

Montreal. Mar. 1st 1928.



CANADIAN NATIONAL RAILWAYS

TELEGRAPH & TELEPHONE DEPARTMENT

TYPICAL BATTERY RACK.