THE ALIGNMENT DIAGRAM APPLIED TO THE FLOW OF WATER IN UNIFORM AND COMPOUND MAINS.*

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(Concluded from last week's issue.)

Irreducible Compound Mains.—Theoretically, the flow in any network of mains is capable of exact determination; practically, however, when it cannot be completely sub-divided into lengths wholly "in series" or wholly "in parallel," trial and error is the best method, and in such cases the carrying power axis facilitates the calculations. When the diameter and length of each component pipe are given, the carrying power of that pipe is known and constant, whatever changes take place in the discharge and loss of head. The flow in each pipe is thus represented by a single index line, such as qph in the key diagram, the locus of which is fixed at one point p. With their respective points p as fulcra, therefore, these index lines have then to be adjusted until the given conditions of discharge and loss of head are fulfilled, as indicated by their intersections on the q- and h-axis.

Practical Application to a Network of Pipes.—The detailed calculations of a compound main, in which are included the different applications of the alignment diagram described above will now be explained.

The general procedure is to determine by means of dsl- and dpl- index lines the values of s or p for each of the component lengths, and to combine these values step by step with the aid of equations (6) and (7) until the carrying power of the whole is obtained. The required diameter and discharge are then determined by dpl- and qph- index lines respectively, each intersecting the p-axis at the value of the carrying power previously calculated. It should be noted that corresponding values of s and p occur at the same point on the p-axis; when, therefore, one of the values has been calculated, the other is obtained from the reading immediately opposite.

Example 9.—Given the compound main shown diagrammatically in Fig. 2 (Plate 2); the diameters and lengths of the component uniform mains are known, and water flows between the points A and B; required—

(1) The diameter of a single uniform main of same length as AB (5.5 miles) equivalent to the compound main;

(2) The rate of discharge assuming a loss of head of 40 ft.

It is convenient to draw up the calculations as shown in the accompanying table. The reference numbers (1) to (10) in the first column correspond to the component mains in Fig. 2. The upper half of the table refers to the determination of s or p from the known diameters and lengths by means of dpl index lines. Thus, for main (1) an index line through d = 10 in. and l = 2 miles intersects the s-scale at 20, and so on. The values omitted in the last two columns are not required. The lower half of the table refers to the combination of the component mains with the aid of equations (6) and (7). Thus, mains (1) and (2) are in series, and equation (6) must be used. Adding together the values of s from the upper half, $s = 24$ for the whole is obtained, and since the corresponding value of p will be required in a later step, $p = 0.2$ is read off opposite 24 on the p-axis and entered in the table. This equivalent main is referred to as (11). Similarly, mains (8), (9), (10) are combined and referred to as (12). Mains (4) and (5) are in parallel, so that equation (7) must be used. Adding together the values of p from upper half, $p = 0.42$ for the whole is obtained, and since the corresponding value of s will be required in a later step, $s = 6$ is read off opposite 0.42 on the p-axis and entered in the table. This equivalent main is referred to as (13), and can now be further combined with main (3), with which it is in series; this is called (14). Mains (11) and (14) are next combined, and so on, until the carrying power (p) = 0.32 for the whole system is obtained.

To find the diameter of a single equivalent uniform main of the same length as AB (5.5 miles), draw an index line through (l) = 5.5 miles and (p) = 0.32; this intersects the d-scale at the required diameter (d) = 14.5 (say 15) in.

To find the discharge, assuming a loss of head of 40 ft., draw an index line through (h) = 40 ft. and (p) = .32; this intersects the q-scale at the required discharge (q) = 1.2 million gallons per twenty-four hours.

Table Showing Method of Calculating the Carrying Power of the Compound Main in Fig. 2.

Reference No.	Diameter. d. (inches)	Length. l. (miles)	For Mains in Series. s.	For Mains in Parallel. p.
(1)	10	2·0	20	—
(2)	15	3·25	4	—
(3)	12	1·5	6	—
(4)	12	2·5	—	0·31
(5)	8	2·5	—	0·11
(6)	12	0·5	2	—
(7)	12	1·0	4	—
(8)	8	2·25	65	—
(9)	6	2·5	350	—
(10)	8	1·0	30	—

Reference No.	Portion of compound main calculated.	Whether in series or in Parallel.	Equation (6) or (7).	s	p
(11)	(1) (2)	Series.	$s = 20 + 4$	24	0·2
(12)	(8) (9) (10)	Series.	$s = 65 + 350 + 30$	445	0·045
(13)	(4) (5)	Parl.	$p = 0·31 + 0·11$	6	0·42
(14)	(3) (13)	Series.	$s = 6 + 6$	12	0·28
(15)	(11) (14)	Parl.	$p = 0·2 + 0·28$	5	0·48
(16)	(15) (6)	Series.	$s = 5 + 12$	7	0·39
(17)	(16) (12)	Parl.	$p = 0·39 + 0·045$	5·5	0·435
(18)	(17) (7)	Series.	$s = 5·5 + 4$	9·5	0·32

Result: The carrying power of the whole compound main is p=0.32.

In the ordinary cartesian system, where the variables are referred to two axes at right-angles to one another, it is not possible to represent a formula of more than three variables without making the diagram unduly involved, whereas in Fig. 1, by means of the alignment system, no fewer than six variables are represented in a very simple way. The advantage of the latter in thus dealing with a large number of variables is, therefore, apparent, for by its use alone has the extension to the calculation of compound mains been made possible.

Appendix.—Rules for Construction.—Like the slide-rule, it is not necessary to understand the principles underlying the alignment diagram in order to employ it in actual practice, and the above examples should serve as sufficient instruction for its use. It is proposed, however, to enter upon a brief discussion of these principles in so far as is necessary to explain the rules for construction. For their proof, reference may be made to the publications given below in the bibliography.