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Description

[0001] The invention relates to a method for balancing a water circulation room heating/cooling system of the type comprising a two-pipe water circulation.

5

[0002] It is known that the balancing of a central heating including warm water circulation consists in making sure that the distribution of the pump flow rate of the water circulation pumps corresponds to the power of the radiators the water flows through. It is known that in such a system the radiators are disposed in a
10 branch between a warm-water feed pipe and a return pipe. Normally, each radiator has a balancing valve the position of which allows a control of the flow of the warm water flowing through the radiator and hence the heat quantity delivered by the radiator. This kind of valve is referred to as a first-level balancing valve because it affords flow control as close to one or several radiators as possible. It is known that in large installations second-level valves are provided that
15 allow controlling the flow of a group of radiators that are balanced among each other using said first-level valves. It is known that in very large installations third-level valves are provided that allow controlling the flow of several groups of radiators that are balanced among each other using said second-level valves.

20

[0003] One of the difficulties encountered when the balancing of this kind of system is poorly performed results from a bad distribution of the flow between the various radiators or radiator groups leading to differences in warming, and these differences even increase when the outside temperatures decrease. Such situations are encountered extremely often, especially in aged systems, and manifest themselves in a lacking user's convenience and in a considerable excess
25 consumption that may reach 10 to 20%.

[0004] The search for a good balance of the system is impeded by the fact
30 that, when a correction of the flow is made on one of the radiators of a system, the flow of the other radiators of the same system is modified at the same time.

[0005] For removing this disadvantage, prior art proposes to calculate the setting position of the entity of the valves of the installation in advance. Such process, which is difficult because of its mere complexity, requires that the system designer has available all the detailed drawings of the system, while in aged installations the user is often compelled to make a completely new chart of the distribution.

[0006] It has also been proposed to carry out such balancing by measuring the flow of the warm water flowing through each valve at specific valves and thereby appropriately correct the flow. This measurement of the flow normally takes place by the measurement of the pressure loss across the flow regulation valve. By subsequently applying various methods, one arrives at a balance, and this more or less easily, depending on the system. The most important drawbacks of this balancing method are that it requires the system to include special valves allowing such a measure being executed and on the other hand that the flow rates are known, which in aged system often requires preparing completely new charts of the distribution.

[0007] In the French application FR-A-2 795 491 and in the case of a regulation of the first-level valves associated with radiators, i.e. with emitters, whose hydraulic resistance is negligible in relation to that of the valves, it is also proposed to measure the temperature of the supply pipes and the return pipes at the level of the radiator located at the most upstream position of the series and to determine the existing temperature difference, in the following referred to as the "reference differential", between said two values, to determine for each radiator of the series the difference between the input temperature of the radiator located at the most upstream position and the output temperature of the radiator being considered, in the following referred to as the "specific difference", to determine a measurement corrector coefficient for each radiator of the series which is equal to the existing difference between the value of the reference differential using a value which is obtained by the existing difference between the above-mentioned value of the reference differential and the above-mentioned value of

the specific difference multiplied by an adjustment coefficient which is found empirically and has a value close to 2.

[0008] By using this method, one has determined a relative flow coefficient for
5 each radiator which is equal to the ratio of the reference differential over the measurement corrector coefficient. In this manner, the flow determined of a radiator is corrected by multiplying its flow by the inverse of the relative flow coefficient. For performing this process, graphs are available which describe the variation of the relative flow $q\%_{Rn}$ of a valve of a given brand and type as a
10 function of the number of turns of its control element at a constant pressure difference.

[0009] These graphs of the relative flow $q\%_{Rn}$ of a valve of a given brand and type as a function of the number of turns N of its control element at a constant
15 pressure difference are provided by the manufacturer or, if not, are measured on a hydraulic test bench. This variation of the relative flow $q\%_{Rn}$ determined in this manner is the variation that is characteristic of a valve of a given brand and type, which is disposed alone without any further hydraulic resistance arranged in series. It will be understood that when the valve is arranged in series with a
20 further hydraulic resistance, the said variation of the relative flow $q\%_{Rn}$ which is characteristic of the valve is not exploitable anymore, especially as this hydraulic resistance is considerable compared to that of the valve.

[0010] That is why such a regulation process is limited to the balancing of first-
25 level valves disposed in series with emitters whose hydraulic resistance is very low such as in radiators or certain convectors. The use of the process is thus limited because these first-level valves are rarely accessible in occupied buildings.

[0011] It is an objective of the present invention to provide a balancing method
30 that can be applied in first-, second- and third-level valves which are arranged in series with emitters and whose hydraulic resistance may be considerable and impossible to be determined. This is the case for example with elements that

cannot be demounted or the measurement or calculation thereof is difficult or impossible because of the frequently lacking charts of distribution and because of the fouling of the interior of the supply pipes and with hydraulic resistances such as those of the columns or the supply pipes of emitters, of heating and
5 cooling batteries, sanitary heating loops etc...)

[0012] Moreover, this method is to prevent that the user is required to use special flow measuring valves or to prepare complex charts or make complex calculations.

10

[0013] Accordingly, the invention is based on the problem of providing a method for balancing a heating/cooling system according to claim 1. The generic part of this claim is disclosed in document EP 0795 724 A1.

15 [0014] It is known that a flow regulating valve, properly dimensioned, in the wide open condition has to have an authority on average of at least 0.5 inclusive with the usual limits of between 0.33 and 0.66 (said authority being defined by the ratio between the hydraulic resistance of the wide open valve over the sum of the hydraulic resistance of the wide open valve and that of the circuit the
20 flow of which is to be regulated by the valve). Accordingly, it was established that the hydraulic resistance of the supply pipes the flow of which must be regulated can be assumed to be equal on average to the hydraulic resistance of regulating valves of the same diameter that best represent the market in the largest opening position and at a limit of between 50% and 200% of this hydraulic
25 resistance.

[0015] Consequently, there can be taken into account such a hydraulic resistance in series with the balancing valves.

30 [0016] The outcome of this is a correction of the variation of the relative flow $q\%_{Rn}$ of a valve of a given brand and type as a function of the number of turns N of its control element, and this at a constant pressure difference, the correction being defined by:

$$q_{vN} = \frac{1}{\sqrt{\frac{1}{q_{v1N}^2} + \frac{1 \text{ [bar]}}{\Delta p \times \kappa_1 \times K_{vS}^2}}} \quad (1)$$

where

5 q_{vN} : is the flow in m³/h of the valve of a given brand and type for a number of turns N under a pressure of Δp in bar, the valve being installed in series with the hydraulic resistance, not demountable and difficult or impossible to calculate

q_{v1N} : is the flow in m³/h of the valve of a given brand and type for a number of turns N under a pressure of Δp in bar as indicated by the manufacturer or as measured on a hydraulic bench

10 Δp : is the pressure for the determination of q_{v1N} in bar

κ_1 : is the authority adjustment coefficient of 1 on average and with a limit comprised between 0.5 and 2

K_{vS} : is the flow in m³/h under 10⁵ Pa of the balancing valves that best represent the market in the wide open position, where:

15

For valves of DN 10 to DN 50:

$$K_{vS} = \frac{177}{DN} + 9,83 \times \sqrt{DN} + 1,39 \cdot 10^{-21} \times e^{DN} - 47,23$$

20 For valves of DN 65 to DN 300:

$$K_{vS} = 0,016 \times DN^2 - 1,14 \cdot 10^{-128} \times e^{DN} - \frac{1,39 \cdot 10^{+29}}{e^{DN}} - 0,54$$

DN in mm	K _{vS} in m ³ /h
10	1,5
15	2,5
20	5,6
25	9

32	13,9
40	19,4
50	33
65	59
80	102
100	159
125	249
150	359
200	640
250	999
300	1232

[0017] The invention will now be described in more detail in the following by way of one embodiment with reference to the attached drawings.

- 5 Figure 1 schematically shows a warm water circulation heating system comprising a series of groups of emitters arranged in a branch between a water feed pipe and a return pipe.

Figure 2 is a graph showing one example of a variation of flow of a valve having a nominal diameter of 25 mm as a function of the number of turns of the valve in the opening direction at a constant pressure difference of 10^5 Pa according to the manufacturer's specifications or as measured on a hydraulic bench.

Figure 3 is a graph showing the corrected variation of the flow of the valve having a nominal diameter of 25 mm as illustrated in Figure 4, arranged in series with a feed circuit having a nominal diameter of 25 mm, exhibiting a high hydraulic resistance, unable to be demounted and difficult or impossible to be calculated, as a function of the number of turns in the opening direction at a constant pressure difference p of 10^5 Pa.

Figure 4 is identical with Figure 3 and shows a graph representing the corrected variation of the flow of the valve having a diameter of 25 mm as defined in Figure 4, installed in series with a circuit having a nominal diameter of 25 mm, exhibiting a high hydraulic resistance, unable to be demounted and difficult or impossible to be calculated, as a function of the number of turns in the opening direction at a constant pressure difference p of 10^5 Pa.

[0018] Figure 1 shows a heating system comprising a warm water feed pipe 1 and a return pipe 3.

10

[0019] Several groups $R_1, R_2, R_3, \dots R_n$ of emitters $E_1, E_2, E_3, \dots E_m$ are respectively arranged in succession and each of these groups R_n of emitters is equipped at the exit thereof with a second-level valve $RO_1, RO_2, \dots RO_n$ allowing to regulate the warm water flow through the valve. In practice, these emitters E_m can be formed by radiators, convectors, heating and cooling batteries as well as by pipes and other associated elements the hydraulic resistance thereof is unknown and is high compared to that of the valve assigned to said group. Accordingly, the regulation situation that is encountered is considerably different from that in which several groups that are comprised of uniform radiators are subject to regulation.

20

[0020] The balancing process of this system consists in providing for the specific flow of each of said groups R_n of emitters corresponding to the respective power.

25

[0021] For balancing such a system in accordance with the invention one proceeds as follows.

[0022] First of all it should be noted that all the temperature measurements within the scope of the implementation of the balancing method of the invention are taken in advance using thermometers having a quasi non-existing thermal inertia and being capable of instantaneously delivering precise measuring results, such as infrared thermometers for example.

30

[0023] Previously to the measurements, the control elements of the balancing valves RO_n assigned to each of the groups R_n of emitters are preferably set in the position of the medium hydraulic opening.

- 5 [0024] Said medium hydraulic opening is defined by the setting position that allows the relative flow of the same amplitude being increased or reduced. This medium hydraulic opening can be clearly different from the mechanical opening when the regulating valve is in series with a hydraulic resistance that is considerable compared to that of the valve.

10

- [0025] According to the invention, there is first of all measured the temperature T_A of pipe 1 at a point A in Figure 1 which is located upstream of the connection of the first group R_1 of emitters for a first time, and there is measured the temperature T_B of pipe 3 at a point B which is located downstream of the connection of the group R_1 of emitters. In this way, the value of $dt_{ref} = T_A - T_B$ can be calculated, hereinafter referred to as the "reference differential".
- 15

[0026] Then the temperature of the pipe located at the exit of each of the groups R_n of emitters is measured, also using an infrared thermometer.

20

[0027] It could be established mainly empirically that the relative flow $Q\%_n$ of a given group R_n of emitters (i.e. the percentage of the initial flow in relation to its "to-be-regulated" flow ") can be expressed as a function of the reference differential and the temperature ts_n of its outlet pipe.

25

$$Q\%_n = \frac{dt_{ref}}{A} = \frac{dt_{ref}}{dt_{ref} - k[dt_{ref} - (t_{ref} - ts_n)]} \cdot 100$$

- [0028] In this formula, a value close to 1.5 is taken for the coefficient k , which is referred to as the "adjustment coefficient", in a first regulation cycle. It could be established from numerous measurements and tests that if the quality of the balance at the end of the first regulation cycle turns out to be non-satisfying, a
- 30

second regulation cycle will have to be performed using a smaller value of this adjustment coefficient k , i.e. close to 1.1.

[0029] One example of carrying out the method of the invention will be described in the following.

EXAMPLE

[0030] In this example, the system comprises a warm-water feed pipe 1 and a return pipe 3 with three groups R_1 , R_2 , R_3 of emitters E_n branched between these pipes. A temperature of the feed pipe 1 at the head of the series is measured $T_A = 60^\circ\text{C}$ at point A, and temperature of the return pipe 3 is measured $T_B = 50^\circ\text{C}$ at point B. The temperatures at the exit of the groups R_1 , R_2 and R_3 of emitters are also measured with $ts_1 = 54^\circ$, $ts_2 = 49^\circ$ und $ts_3 = 45^\circ$, respectively.

In this way, the reference differential $dt_{\text{ref}} = 10^\circ\text{C}$ is obtained. Thereafter, a calculation is made for the group R_1 of emitters using the following formula (2), and there is obtained:

$$Q\%_{R1} = \frac{10}{10 - 1.5 \cdot [10 - (60 - 54)]} \cdot 100 = 250\%$$

[0031] The relative flow $Q\%_{R1}$ of 250% obtained for the group R_1 of the emitters shows that the initial flow of this series of emitters is 2.5 times larger and that it must therefore be reduced by the same ratio of 2.5 and that the regulating valve RO_1 must be closed in such a manner that its flow is divided by 2.5.

[0032] One proceeds in the same manner for the group R_2 of emitters:

$$Q\%_{R2} = \frac{10}{10 - 1.5 \cdot [10 - (60 - 49)]} \cdot 100 = 87\%$$

[0033] The relative flow $Q\%R_2$ of 87% obtained for the group R_2 of the emitters shows that the initial flow of this group of emitters is 87/100 of that it ought to be and that its flow 5 must hence be augmented at a ratio of $100/87 = 1.15$ und the regulating valve RO_2 must be opened in such a manner that its flow is multiplied by 1.15.

[0034] For the group R_3 of the emitters there is similarly obtained:

$$Q\%_{R3} = \frac{10}{10 - 1,5[10 - (60 - 45)]} \cdot 100 = 57,1\%$$

10

[0035] This means that the regulating valve RO_2 must be opened in such a manner that its flow is multiplied by $100/57,1 = 1,75$.

[0036] Should the case arise that the obtained relative flow $Q\%_{RN}$ is either negative or infinite, the initial flow may be considered as still being excessively high so that the setting of the corresponding valve RO_n must be changed to the minimum setting position.

[0037] To allow this process being carried out easily and quickly for each of the groups R_n of emitters, charts are at hand in which the variation of the flow qv_N of the valve RO_n of a given brand and type is expressed as a function of the number of turns n of the control element of said valve at a constant pressure difference. Such a chart, which can be provided by the manufacturer or can be established by measurements on a hydraulic bench, is shown in an exemplary manner in Figure 2 for a nominal diameter of 25 mm of a valve 8 T, measured under a pressure of 10^5 Pa.

Valve position	Flow in m^3/h under a pressure of 10^5 Pa
8	10
6	8,2
4	6

2	3,2
---	-----

[0038] It has been determined mainly empirically that these values have to be subject to a corrector coefficient. The computation of the correction for the valve RO_n is made according to formula (1):

5

$$q_{vN} = \frac{1}{\sqrt{\frac{1}{q_{v1N}^2} + \frac{1 [\text{bar}]}{\Delta p \times \kappa_1 \times K_{vS}^2}}}$$

where

$$q_{v8} = \frac{1}{\sqrt{\frac{1}{10 \times 10} + \frac{1}{1 \times 1 \times 9^2}}} = 6,69 \text{ m}^3 / \text{h}$$

10

$$q_{v6} = \frac{1}{\sqrt{\frac{1}{8,2 \times 8,2} + \frac{1}{1 \times 1 \times 9^2}}} = 6,06 \text{ m}^3 / \text{h}$$

$$q_{v4} = \frac{1}{\sqrt{\frac{1}{6 \times 6} + \frac{1}{1 \times 1 \times 9^2}}} = 4,99 \text{ m}^3 / \text{h}$$

15

$$q_{v2} = \frac{1}{\sqrt{\frac{1}{3,2 \times 3,2} + \frac{1}{1 \times 1 \times 9^2}}} = 3,02 \text{ m}^3 / \text{h}$$

[0039] If these values are transferred to the graph of Figure 2, a curve (a) is obtained which lies under curve (b) (Figure 3).

20 [0040] For each of the valves RO₁, RO₂ and RO₃ the initial setting position of the valve is known. It is therefore assumed that the valve has initially been set to the medium hydraulic opening which in the graph of Figure 4 corresponds to a position of 2.25 turns (N=2.25) at a flow of 3,3 m³/h, i.e. a position that is ob-

tained starting from the closed position as a reference value and thereafter turning the valve by 2.5 turns.

[0041] Accordingly, the first group R_1 of emitters whose flow must be reduced
 5 by a ratio of 2.5, must be brought to a flow of its valve RO_1 of $3,3/2,5 = 1,3 \text{ m}^3/\text{h}$, and the graph of Figure 4 shows that this flow is obtained at a position $N_1 = 0,87$ of the valve RO_1 . To bring this valve from the medium hydraulic opening to this position, which corresponds to an opening of 0.87 turns, under these conditions, the valve must be closed by a value of $2.75-0.875 = 1.87$ turns.

10

[0042] This similarly applies to the group R_2 of the emitters whose flow must be augmented by a ratio of 1.15. The flow of the associated valve RO_2 must be brought to a flow of $3.3 \times 1.15 = 3.8 \text{ m}^3/\text{h}$, and the graph of Figure 4 shows that the control element of valve must be turned to bring it to a position correspond-
 15 ding to $N=2.75$ opening turns.

[0043] Of course, the process is the same for the group R_3 of the emitters whose flow must be augmented by a ratio of 1.75. The flow of its valve RO_3 must be brought to a flow of $3.3 \times 1.75 = 5.77 \text{ m}^3/\text{h}$, and the graph of Figure 4
 20 shows that valve has to be brought to the position of $N_3 = 5.37$. Accordingly, the valve must be closed by $5.375-2.25=3.12$ turns.

[0044] It has been determined that the system is balanced or quasi balanced once these regulations are completed. Nevertheless, it may turn out in some
 25 cases of this regulation that a second regulation cycle is required. In such a case, the above-described operations are repeated in an identical manner, however using a value of the coefficient k which, as trial and tests have shown, has to be smaller than or close to 1.1.

[0045] If it turns out that during the first regulating cycle the valve has been excessively closed or excessively opened, the authority coefficient k_1 is corrected by being increased by a value having an upper limit of 2.

30

- [0046] If it turns out that during the first regulating cycle the valve has been insufficiently closed or insufficiently opened, the authority coefficient k_1 is corrected by being decreased by a value having a lower limit of 0.5.
- 5 [0047] The process of the invention can be carried out manually by making the above-described calculations, although it would be easier to use a device guiding the user through the process and if certain operations were automated, particularly the calculations.
- 10 [0048] Although the above examples have been described in connection with a warm-water circulation system for heating a room, all the described processes and operations can also be used in a cold-water circulation system for cooling said room.

Patentkrav

1. Fremgangsmåde til balancering af et opvarmnings/afkølingssystem med cirkulerende vand omfattende mindst en række sæt (R_1, R_2, R_n) af emittere (E_1, E_2, E_n) hvor hvert sæt (R_1, R_2, R_n) af emittere (E_1, E_2, E_n) er anbragt i afledningen mellem en opstrøms vandfødekanal (1) og en nedstrøms returkanal (3) med hvert sæt (R_1, R_2, R_n) af emittere (E_1, E_2, E_n) i stand til at blive justeret individuelt med mindst et første niveau balanceventil (RO_1, RO_2, RO_n), **kendetegnet ved**, at den omfatter trinnene bestående af:
- 10
- måling af temperaturen (T_A) af fødekanalen (1) opstrøms for serierne og bestemmelse af temperaturforskellen eller referencedifferentialet (dt_{ref}) mellem denne temperatur (T_A) og en temperatur (T_S) lig med enten temperaturen af returkanalen (3) opstrøms for rækkerne eller en temperatur lig med den ønskede temperatur for denne kanal,
 - 15
 - successiv måling af temperaturen (ts_n) ved udgangen af hvert sæt (R_1, R_2, R_n) af emittere (E_1, E_2, E_n) af rækkerne,
 - successiv måling for hvert sæt (R_1, R_2, R_n) af emittere (E_1, E_2, E_n) af forskellen mellem temperaturen (T_A) opstrøms for det første sæt af emittere (R_1) og udgangstemperaturen (ts_n) af hvert sæt (R_1, R_2, R_n) af emittere (E_1, E_2, E_n), af specifik forskel,
 - 20
 - etablering for hvert sæt (R_1, R_2, R_n) af emittere (E_1, E_2, E_n) af en målingskorrekturkoefficient (A) lig med forskellen, som eksisterer mellem værdien af referencedifferentialet (dt_{ref}) og en værdi, som udgøres af produktet af en justeringskoefficient (k) af forskellen, som eksisterer mellem den ovennævnte værdi af referencedifferentialet (dt_{ref}) og den ovenfor nævnte værdi af den specifikke differens,
 - 25
 - etablering for hvert sæt (R_1, R_2, R_n) af emittere (E_1, E_2, E_n) af en relativ strømningskoefficient ($Q\%_n$) lig med forholdet mellem referencedifferentialet (dt_{ref}) og målingskorrekturkoefficienten (A).
 - 30

2. Fremgangsmåde ifølge krav 1, **kendetegnet ved**, at justeringskoefficienten (k) er tæt på 1,5 ved en første justeringscyklus og tættere på 1,1 for de eventuelt efterfølgende cyklusser.
- 5 3. Fremgangsmåde ifølge et af kravene 1 eller 2, **kendetegnet ved**, at strømningen tilvejebragt for et givet sæt af emittere korrigeres ved at multiplicere dets gennemstrømning med den reciprokke værdi af den relative strømningskoefficient.
- 10 4. Fremgangsmåde ifølge krav 3, **kendetegnet ved**, at positioneringen af det ventiljusterende element (RO_n) til regulering tilvejebringes med reference til det hydrauliske respons af denne ventil under konstant tryk, korrigeret for den hydrauliske modstand i række ifølge formlen:

15
$$q_{vN} = \frac{1}{\sqrt{\frac{1}{q_{v1N}^2} + \frac{1 \text{ [bar]}}{\Delta p \times k_1 \times K_{vs}^2}}}$$

hvor

- q_{vN} er gennemstrømningen i m^3/t af ventilen,
- q_{v1N} er gennemstrømningen i m^3/t af ventilen som indikeret af leverandøren eller
- 20 som målt på en hydraulisk bæk,
- Δp er trykket for bestemmelsen af q_{v1N} i bar,
- k_1 er autoritetsjusteringskoefficienten,
- K_{vs} er gennemstrømningen i m^3/t ved $10^5 Pa$ af de balancerende ventiler, som bedst repræsenterer markedet i fuld åben position.

25

5. Fremgangsmåde ifølge krav 4, **kendetegnet ved**, at når en ventil ved en første justering, fuldstændigt åben eller fuldstændigt lukket, er autoritetsjusteringskoefficienten (k_1) forbundet med sidstnævnte korrigeret ved at øge den med en øvre grænseværdi på 2.

30

6. Fremgangsmåde ifølge krav 4, **kendetegnet ved**, at når en ventil fra en første justering utilstrækkeligt åben eller utilstrækkeligt lukket, korrigeres autoritetskoefficienten på 1 forbundet med sidstnævnte ved at mindske den med en lav grænseværdi på 0,5.

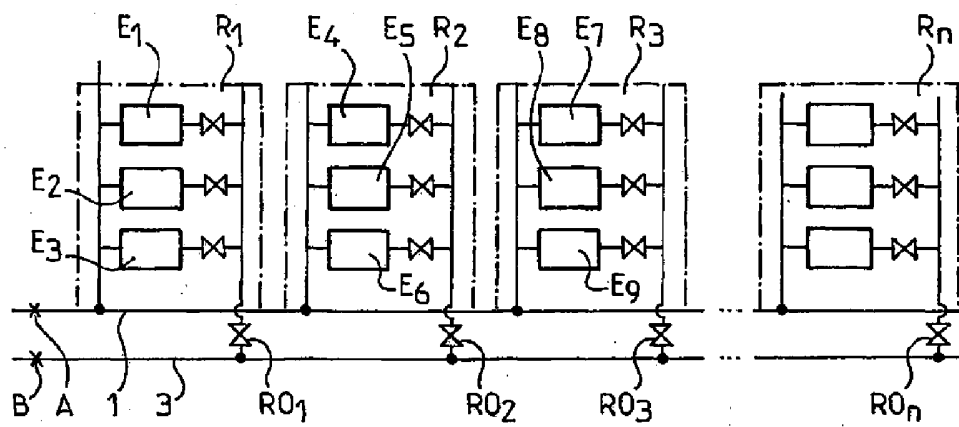


FIG.1

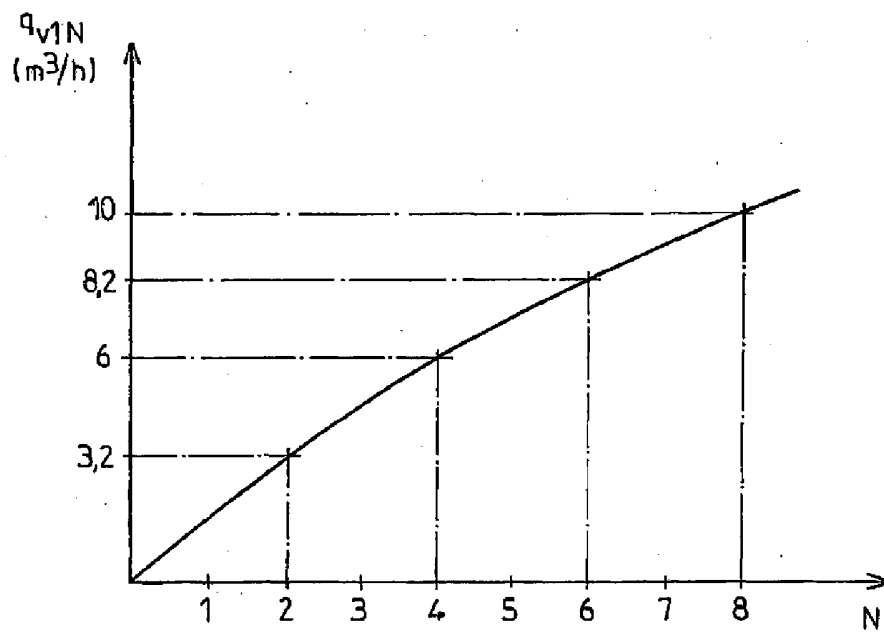


FIG.2

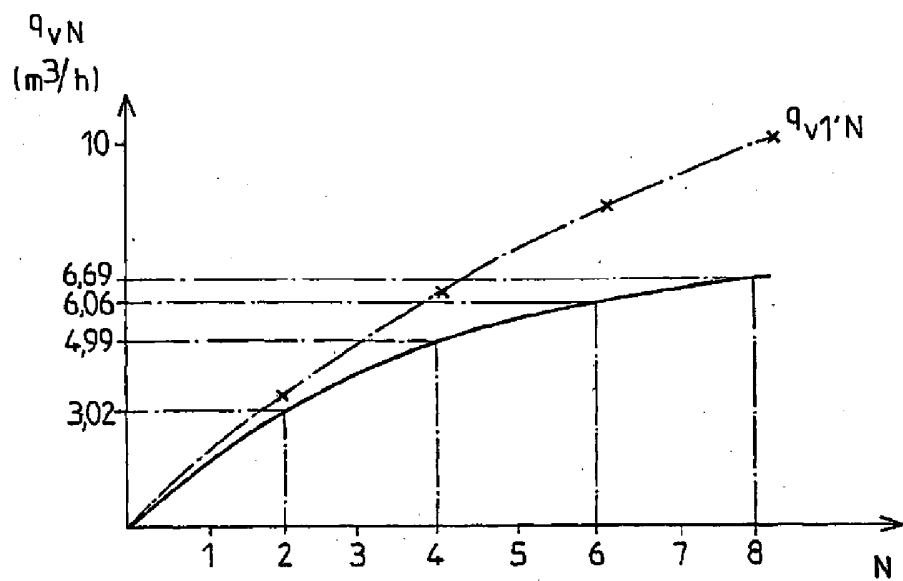


FIG. 3

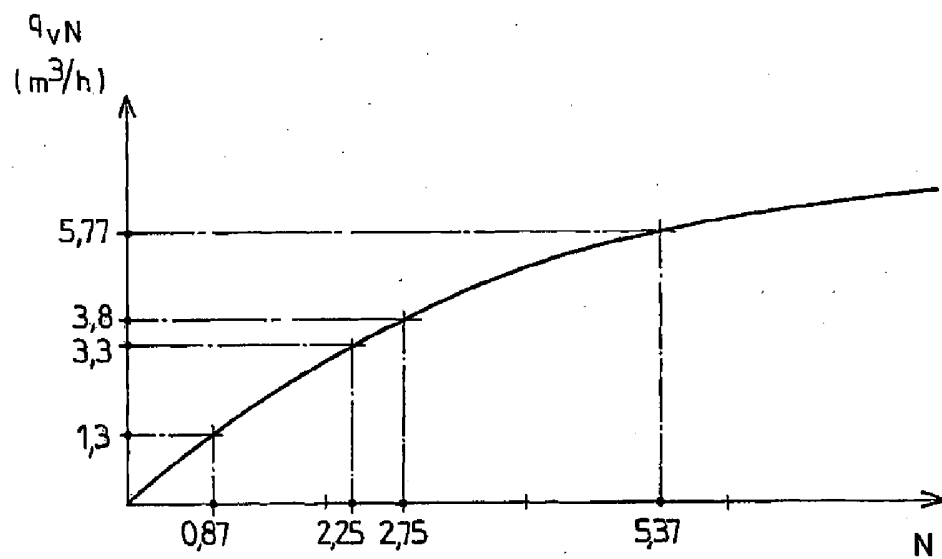


FIG. 4