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Description

The invention relates to a controller for a tunnel ventilating system for ventilating a tunnel having a ventilating shaft substantially at the middle of the tunnel, an exhaust blower within the ventilating shaft, jet fans within the tunnel, detecting means for detecting various physical values representing the degree of air pollution within the tunnel, and processing means for processing the physical values detected by the detecting means to control the operation and flow rate of the exhaust blower and the jet fans.

Automobile traffic tunnels and railway tunnels, particularly for diesel or steam trains need to be ventilated continuously to prevent the danger of the tunnels being filled with exhaust gas or steam discharged by the automobiles or the locomotives. Accordingly, such tunnels are equipped with ventilating holes, exhaust blowers and supply blowers.

JP-A-5944499 discloses a tunnel ventilating system including a controller as illustrated in a block diagram of Fig. 1. Fig. 2A shows a schematic view of the whole tunnel section including a ventilating shaft, Fig. 2B is a diagram showing the distribution of the degree of pollution within the tunnel under normal conditions, and Figs. 3A and 3B show similar diagrams under the condition that a blow-through occurs on one or the other portal of the tunnel.

Referring to Fig. l, a vertical ventilating shaft l is formed substantially at the middle of a tunnel 2 and an exhaust blower 3 for discharging polluted air from the tunnel 2 is provided in the ventilating shaft 1. Jet fans 4a and 4b for driving the polluted air toward the ventilating shaft l are attached to the ceiling of the tunnel 2. A controller l0 for controlling the exhaust blower 3 and the jet fans 4a and 4b controls the ventilating system on the basis of data obtained by sensors 6 and 7 for detecting the degree of air pollution and other data, attached to the ceiling of the tunnel 2 on the opposite sides of an opening la of the ventilating shaft l, respectively. The controller l0 comprises a program control unit ll which determines the mode of operation of the exhaust blower 3 and the jet fans 4a and 4b, such as the number of operating units and rotating speed of the exhaust blower 3 and the jet fans 4a and 4b, according to a program stored in a memory device, not shown; a manual control unit l2 which determines the mode of operation of the exhaust blower 3 and the jet fans 4a and 4b, such as the number of operating units and rotating speed of the exhaust blower 3 and the jet fans 4a and 4b, according to instructions given to the controller l0; an input data processing unit l3 which receives detection signals periodically from the sensors 6 and 7 and averages the detection signals; a software switching unit l4 which sets the data processing timing of the program control unit ll; operation mode correcting unit l5 which receives the output signal of the program control unit ll controlled by the switching unit l4, the output signal of the manual control unit l2 and the output signal of the input data processing unit l3, and then corrects control patterns specified by the control units ll and l2 on the basis of data processed by the input data processing unit l3; and a control pattern determining unit l6 which determines an actual mode of operation of the exhaust blower 3 and the jet fans 4a and 4b on the basis of the output signal of the operation mode correcting unit l5 and provides control signals. A manual instruction given by external means to the manual control unit l2 is switched by a switching unit l7. The control pattern determining unit l6 of the controller l0 is connected to the exhaust blower 3 and the jet fans 4a and 4b by a control circuit l8.

The controller l0 thus constituted for controlling the tunnel ventilating system measures the degree of pollution of the air within the tunnel 2 by means of the sensors 6 and 7, and then controls the exhaust blower 3 and the jet fans 4a and 4b on the basis of the measured data. Measured degrees of pollution x and y in sections A and B between the portal 2a of the tunnel 2 and the opening la of the ventilating shaft l and between the portal 2b of the tunnel 2 and the opening la of the ventilating shaft l, respectively, as shown in Fig. 2A vary along characteristic curves shown in Fig. 2B. When fresh air is supplied through the portals 2a and 2b of the tunnel 2 toward the ventilating shaft l as illustrated in Fig. 2A, the degree of pollution is highest in a region in the vicinity of the opening la of the ventilating shaft l as illustrated in Fig. 2B, and hence it is possible to control the ventilation of the tunnel 2 on the basis of the data x and y measured by the sensors 6 and 7.

However, the flow of the fresh air within the tunnel 2 is affected by the difference in atmospheric pressure between the portals 2a and 2b of the tunnel 2, the number, direction and type of vehicles, such as automobiles or trains, which run through the tunnel 2. Therefore, it is difficult to maintain the distribution of degree of pollution as illustrated in Fig. 2B. In some cases, so-called blow-through occurs in the tunnel 2, in which fresh air flows only in one direction from the portal 2a toward the portal 2b or from the portal 2b toward the portal 2a and the air within the tunnel 2 is scarcely ventilated through the ventilating shaft l. When flow-through occurs, the distribution of the degree of pollution assumes values as illustrated in Fig. 3A or 3B. In Figs. 3A and 3B, blank arrows indicate the direction of flow of fresh air within the tunnel 2. As is obvious from Figs. 3A and 3B, the degree of pollution at the outlet portal 2a or 2b exceeds an allowable level indicated by a dotted line. When the measured degree of pollution x or y at the portal 2a or the portal 2b is excessively high, it is impossible to control the ventilation of the tunnel 2 on the basis of the difference between the degree of pollution measured by the sensor 6 and the degree of pollution measured by the sensor 7. To reduce the degree of pollution below the allowable level after the distribution of the degree of pollution has become a state as illustrated in Fig. 3A or 3B, the inclination of the distribution curves x-y needs to be reduced by increasing the rate of ventilation, which requires a ventilating system having a large supply capacity or a large exhaust capacity. Consequently, such a tunnel ventilating system would be expensive and required increased power cost, and hence such a tunnel ventilating system would be economically disadvantageous.

Another tunnel ventilation control system is known from JP-A-5412137. In this known system, the accuracy of control is increased by correcting a long-term control based on long-term traffic data by data about contamination averaged from short-time fluctuations in the quantity of contamination to obtain an optimal control in dependence of fluctuations of traffic. This system, however, does not deal with the problem of blow-through from one or the other side of the tunnel as explained in connection with Figs. 3A and 3B above.

It is an object of the present invention to provide a controller for tunnel ventilating systems, capable of always stably controlling the degree of pollution of the tunnel below an allowable level by controlling the tunnel ventilating system in such a way that fresh air will flow at an appropriate flow rate and at an appropriate air flow speed from both the portals of the tunnel towards the opening of the ventilating shaft formed substantially at the middle of the tunnel. It is a particular object of the present invention to provide such an operation without requiring the tunnel ventilating system having a larger ventilating capacity in order not to increase the equipment costs and power costs.

This object of the invention is solved by a controller for a tunnel ventilating system which is characterized by further detecting means disposed with the tunnel and/or at the portals of the tunnel, respectively, for measuring the air flow speed within the tunnel, the difference in atmospheric pressure between the portals and the traffic volume and driving speed of vehicles passing through the tunnel; in that in the the processing means the long-term traffic volume is calculated on the basis of the values detected by traffic volume detectors provided at and/or near the portals of the tunnel for controlling the exhaust blower and the jet fans; and in that the processing means are provided with a flow rate correcting unit for finalizing the control of the exhaust blower in dependance of the values detected by the air pollution detecting means and the traffic volume detectors on a short-term basis.

Preferable embodiments are defined in the dependent claims.

Figure I is a block diagram of a conventional tunnel ventilating system and a controller for controlling the same shown in combination with a schematic sectional view of a traffic tunnel;

Figures 2A and 2B are a schematic sectional view of a tunnel and a diagram showing the distribution of the degree of pollution within the tunnel, respectively;

Figures 3A and 3B are diagrams showing the distribution of the degree of pollution within a tunnel when blow-through occurred;

Figure 4 is a block diagram of a controller for tunnel ventilating systems, in a first embodiment, according to the present invention;

Figure 5 is a flow chart for explaining the manner of control operation of the controller of Fig. 4; and

Figure 6 is a block diagram of a controller for tunnel ventilating systems, in a second embodiment, according to the present invention.

Preferred embodiments of the controller for tunnel ventilating systems, according to the present invention will be described hereinafter with reference to the accompanying drawings.

In Fig. 4, the constitution and arrangement of a ventilating shaft I, an inner opening Ia of the ventilating shaft I, a tunnel 2, portals 2a and 2b, and an exhaust blower 3 are the same as those of the conventional tunnel ventilating system and the tunnel shown in Fig. I, hence the description thereof will be omitted to avoid duplication. A tunnel ventilating system I9 comprises the exhaust blower 3 and jet fans 4 and 5. The jet fans 4 and 5 are disposed within the tunnel 2 on opposite sides of the opening Ia of the ventilating shaft I to supply fresh air from the portals 2a and 2b toward the opening Ia. A detecting system 20 for detecting various physical values is provided within the tunnel 2. The detecting system 20 comprises air pollution sensors 2I and 22, such as visibility index meters (hereinafter designated as "VI meters") or carbon monoxide concentration detecting meters (hereinafter designated as "CO meters"), anemometers 23 and 24 attached to the ceiling of the tunnel 2 on opposite sides of the opening Ia to detect the respective flow speeds of air flowing from the portal 2a toward the opening Ia and air flowing from the portal 2b toward the opening Ia, respectively, microbarometers 25a and 25b attached to the ceiling of the tunnel 2 near the portals 2a and 2b to measure the atmospheric pressure near the portals 2a and 2b, respectively;

traffic volume detectors 26a and 26b disposed near the portals 2a and 2b, respectively, to detect the type, number and driving speed of automobiles coming into the tunnel, and traffic volume detectors 27a and 27b disposed outside the tunnel at a fixed distance from the portals 2a and 2b to detect the type, number and speed of automobiles driving on approaches to the tunnel 2.

The data acquired by the detectors of the detecting system 20 are operated and processed by a processing unit 30 comprising a basic logic unit 3l which calculates a long-term traffic volume estimate, a degree of pollution, a required ventilating rate and a flow rate allocation on the basis of data acquired by the traffic volume detectors 26a, 26b, 27a and 27b, a flow rate correcting unit 32 which corrects the flow rate on the basis of data acquired by the air pollution sensors 2l and 22 and the output signal of the basic logic unit 3l, and a flow speed control unit 33 which controls the flow speed of air within the tunnel 2 on the basis of air flow speed data detected by the anemometers 23 and 24, atmospheric pressures near the portals 2a and 2b detected by the microbarometers 25a and 25b, traffic volume detected by the traffic volume detectors 26a, 26b, 27a and 27b and the output signal of the basic logic unit 3l. The exhaust blower 3 of the tunnel ventilating system l9 is controlled by a blower control circuit 34 according to the output signals of the flow rate correcting unit 32 of the processing unit 30. The jet fans 4 and 5 of the tunnel ventilating system l9 are controlled by a jet fan control circuit 35 on the basis of the output signals of the flow speed control unit 33.

The manner of operation of the controller for the tunnel ventilating system will be described hereinafter with reference to Figs. 4 and 5.

The basic logic unit 3l of the processing unit 30 executes a long-term traffic volume estimating task 4l to estimate a traffic volume at a time in the subsequent 30 to l20 min on the basis of various traffic volume data T_D concerning automobiles passing through the tunnel 2, such as the time series data of the number of automobiles classified by type and the driving speed of automobiles, detected by the traffic volume detectors 26a, 26b, 27a and 27b, and then the basic logic unit 3l executes a pollution level calculating task 42 to calculate a pollution level within the tunnel 2 under the estimated traffic volume. Then, the basic logic unit 3l executes a ventilation demand calculating task 43 to calculate a ventilation rate necessary to maintain the degree of pollution within the tunnel 2 below an allowable degree of pollution. The exhaust blower 3 and the jet fans 4 and 5 of the ventilating system l9 are operated for a ventilation rate exceeding the ventilation demand calculated in the ventilation demand calculating task 43 to attain a control target. However, the operation of the ventilating system l9 at an excessively high rate would increase the power cost wastefully. Accordingly, to select the most economical operation pattern among the operation pattern of the ventilating system l9 meeting the ventilation demand, a flow rate allocation calculating task 44 is executed. After accomplishing the tasks 4l to 44, the basic logic unit 3l provides a reference air flow speed S_R, a reference ventilation rate R_R, and a reference jet fan number N_R. The reference air flow speed S_R is the speed in the sections of the tunnel 2 on the opposite sides of the opening la, respectively, when the ventilating system l9 is operated in the operation pattern selected through the flow rate allocation calculating task 44. The reference ventilation rate R_R is an exhaust rate of the exhaust blower 3 when the ventilating system l9 is operated in the selected operation pattern. The reference jet fan number N_R is the number of jet fans to be operated among the jet fans 4 and 5 when the ventilating system l9 is operated in the selected operation pattern. The tunnel ventilating operation is carried out on the basis of those reference values provided by the basic logic unit 3l. The basic logic unit 3l is actuated every 30 to l20 min to update the reference values.

The flow rate correcting unit 32 of the processing unit 30 carries out the following functions. Traffic volume in the tunnel 2 is variable and does not remain constant for 30 to l20 minutes. Since the basic logic unit 3l is actuated every 30 to l20 minutes, the traffic volume data T_D needs correction, and hence the reference values calculated by the basic logic unit 3l also need correction. The flow rate control unit 32 executes a short-term traffic volume estimating task 45 on the basis of the time series data provided by the traffic volume detectors 26a, 26b, 27a and 27b to estimate a short-term traffic volume. Then, a traffic volume feed forward control task 46 is executed to calculate a correction by comparing the estimated short-term traffic volume and the estimated long-term traffic volume obtained through the long-term traffic volume estimating task 4l by the basic logic unit 3l. An air pollution feedback control task 47 is executed to calculate an air pollution degree correction by comparing a measured air pollution degree P_M and an air pollution degree target P_T. Generally, the air pollution degree feedback control operation is a VI feedback control operation based on a measured haze transmissivity and its reference value, or a CO feedback control operation based on a measured CO concentration and its reference value.

The flow rate correcting unit 32 adds the reference ventilation rate R_R and corrections obtained through the traffic volume feed forward task 46 and the air pollution feedback control task 47 by means of an adder 48 to provide a final control value 50 of flow rate for the exhaust blower 3. The flow rate control unit 32 is actuated every approximately l0 minutes, because excessively frequent change of the operating condition of the exhaust blower 3 having a large capacity affects adversely to the durability of the exhaust blower 3 and the variation of air pollution degree within the tunnel 2 in a time of about one minute is insignificant.

The flow speed control unit 33 of the processing unit 30 carries out the following functions. Generated in the tunnel 2 are various forces affecting the movement of air within the tunnel 2, such as ventilating forces generated by the running of vehicles, natural draft forces attributable to atmospheric pressure differences between the portals of the tunnel 2, pressure raising forces resulting from the ventilating operation of the tunnel ventilating system l9, frictional resistance of the walls of the tunnel 2 against the flow of air, resistances at the portals causing a loss in air flow force and other various forces. To correct the variation of the flow speed of air within the tunnel resulting from the influence of these forces, namely, to maintain the air flow speed within the tunnel at the reference air flow speed S_R calculated by the basic logic unit 3l, a pressure balance calculating task 5l is executed to calculate a pressure balancing value on the basis of the traffic volume data T_D, a natural inflow rate R_N and the reference air flow speed S_R. Then, an air flow speed feedback control task 52 is executed to calculate a correction by comparing the reference air flow speed V_R and a measured air flow speed S_M measured by the anemometers 23 and 24. The flow speed control unit 33 adds the reference jet fan number N_R provided by the basic logic unit 3l, the pressure balancing value obtained through the tasks 5l and 52, and a feedback air flow speed correction, and then provides a jet fan control value 55 for controlling the number of the jet fans to be operated among the jet fans 4 and 5, and the rotating speed of the jet fans.

The calculating operation of the flow speed control unit 33 needs to be executed at an interval smaller than those of operation of the basic logic unit 3l and the air flow speed correcting unit 32, because, when an automobile drives through the tunnel 2, for example, from the portal 2b toward the portal 2a (Fig. 4), it passes through the section A in L_1/V sec and the section B in L_2/V sec, where L_1 - (m) is the distance between the portal 2a and the opening la of the ventilating shaft l, L_2 (m) is the distance between the portal 2b and the opening la of the ventilating shaft l, and V (m/sec) is the driving speed of the automobile.

On the other hand, during the stabilized ventilating operation, the air flows within the tunnel 2 from the portal 2a toward the ventilating shaft l in the section A and from the portal 2b toward the ventilating shaft l in the section B. However, the ventilating force generated by the automobile driving from the portal 2b toward the portal 2a always acts along a direction from the portal 2b to the portal 2a. Accordingly, the ventilating force generated by the automobile acts against the ventilation while the automobile is driving in the section B, while the ventilating force generated by the automobile acts for the ventilation while the automobile is driving in the section A. Therefore, the air flow speed control unit 33 needs to operate at an interval smaller than the smaller one of the times L_1/V sec and L_2/V sec. For example, when $L_1 \cong L_2 \cong$ 3000 m and V = 60 km/hr, appropriate intervals for the operation of the air flow speed control unit 33 is in the range of one to three minutes.

Thus, economical, stable ventilation control of the centralized exhaustion system is realized by executing the control software of the basic logic unit 3l, flow rate correcting unit 32 and air flow speed control unit 33 of the processing unit 30 at appropriate intervals meeting the respective functions and objects of the component units of the processing unit 30, respectively.

As described with reference to Fig. 5, in the first embodiment, the air flow speed correcting unit 32 executes the traffic volume feed forward control task 46 and the air pollution degree feedback control task 47 to obtain two corrections. However, a control value 50 for controlling the exhaust blower 3 may be obtained on the basis of one or the other of the two corrections.

Furthermore, when the present invention is applied to a controller for a ventilating system of a small scale, the flow rate correcting unit 32 may be omitted and the processing unit 30 may comprise only the basic logic unit 3l and the air flow speed control unit 33.

Still further, although the first embodiment of the present invention has been described as applied to the tunnel ventilating system l9 comprising the exhaust blower 3 and the jet fans 4 and 5, the application of the present invention is not limited thereto, but may be applied, in a second embodiment as illustrated in Fig. 6, to a tunnel ventilating system 59 comprising an exhaust blower 3, jet fans 4 and 5, and electric dust collectors 6l and 62 for collecting dust from the air within the tunnel. In the second embodiment, the controller may include an exhaust and dust collection control circuit 64, and an electric dust collector control unit 60 for controlling the operation of the electric dust collectors on the basis of a flow rate correction value. In such a case, the control value 50 for controlling the exhaust blower 3 is used as a controlled value for controlling the exhaust blower 3 and the dust collectors 6l and 62.

As is apparent from the foregoing description, the controller for tunnel ventilating systems, according to the present invention controls the tunnel ventilating system to regulate the flow speed and flow rate of air within the tunnel on the basis of control values obtained by operating and processing information detected by detectors for detecting various physical values representing the degree of air pollution within the tunnel, and thereby the ventilating system is controlled for stable, economical ventilating operation, in which air flows always from both the portals of the tunnel toward the ventilating shaft.

Claims

1. A controller for a tunnel ventilating system for ventilating a tunnel (2) having a ventilating shaft (1) substantially at the middle of the tunnel, an exhaust blower (3) within the ventilating shaft (1), jet fans (4, 5) within the tunnel (2), detecting means (21, 22) for detecting various physical values representing the degree of air pollution within the tunnel (2), and processing means (30) for processing the physical values detected by the detecting means (21, 22) to control the operation and flow rate of the exhaust blower (3) and the jet fans (4, 5),
characterized by further detecting means (23, 24; 25a, 25b; 26a, 26b) disposed within the tunnel and/or at the portals (2a, 2b) of the tunnel (2), respectively, for measuring the air flow speed within the tunnel (2), the difference in atmospheric pressure between the portals (2a, 2b) and the traffic volume and driving speed of vehicles passing through the tunnel (2); in that in the processing means (30) the long-term traffic volume is calculated on the basis of the values detected by traffic volume detectors (26a, 26b; 27a, 27b) provided at and/or near the portals (2a, 2b) of the tunnel (2) for controlling the exhaust blower (3) and the jet fans (4, 5); and in that the processing means (30) are provided with a flow rate correcting unit (32) for finalizing the control of the exhaust blower (3) in dependance of the values detected by the air pollution detecting means (21, 22) and the traffic volume detectors (26a, 26b; 27a, 27b) on a short-term basis.

2. A controller as claimed in claim 1,
characterized in that a part (33, 35) of the processing means (30) processes the physical values dtected by the further detecting means (23, 24; 25a, 25b; 26a, 26b) to control the jet fans (4, 5) in such a way that a fresh air flow is maintained in the tunnel (2) at an appropriate flow speed from both portals (2a, 2b) towards the ventilating shaft (1).

3. A controller as claimed in claim 1 or 2,
characterized by electric dust collectors (61, 62) provided within the tunnel (2) on opposite sides of the ventilating shaft (1) to collect and remove dust from the tunnel, the electric dust collectors (61, 62) being controlled together with the exhaust blower (3) by the flow rate correcting unit (32).

4. A controller as claimed in claim 1 or 2, wherein said processing means (30) comprises: a basic logic unit (31) which sequentially calculates a long-term traffic volume estimate, an air pollution degree within the tunnel (2), a ventilation demand and a flow rate allocating value on the basis of the physical values detected by the traffic volume sensors (26a, 26b; 27a, 27b) to determine a reference flow speed, a reference ventilation demand and a reference number of jet fans (4, 5) to be operated;
a flow rate correcting unit (32) which calculates a short-term traffic volume estimate for a feedback control of the tunnel ventilating system on the basis of the values detected by the traffic sensors (26a, 26b; 27a, 27b) and an air pollution degree for the feedback control of the tunnel ventilating system on the basis of an air pollution degree detected by the air pollution degree sensor (21, 22), and adds the short-term traffic volume estimate and the air pollution degree to provide a controlled flow rate of the exhaust blower (3); and
a flow speed control unit (33) which calculates the pressure balance within the tunnel (2) on the basis of a flow speed detected by the flow speed sensors (23, 24) of the detecting means, a traffic volume detected by the traffic volume sensors (26a, 26b; 27a, 27b) and the reference flow speed, calculates a flow speed for the feedback control of the tunnel ventilating system on the basis of the flow speed within the tunnel (2) detected by the flow speed sensors (23, 24) and the reference flow speed at the output of the basic logic unit (31), and adds both the calculated values and the reference flow speed to provide a controlled flow speed for controlling the operation of the jet fans (4, 5).

Revendications

1. Dispositif de régulation pour un système de ventilation de tunnel destiné à la ventilation d'un tunnel (2) comprenant un puits de ventilation (1) situé sensiblement au milieu du tunnel,

une soufflerie d'évacuation (3) située à l'intérieur du puits de ventilation (1), des ventilateurs à jet (4, 5) situés dans le tunnel (2), des moyens de détection (21, 22) servant à détecter diverses valeurs physiques représentatives du degré de pollution d'air à l'intérieur du tunnel (2), et des moyens de traitement (30) servant à traiter les valeurs physiques détectées par les moyens de détection (21, 22) afin de régler le fonctionnement et le débit de la soufflerie d'évacuation (3) et des ventilateurs à jet (4, 5), caractérisé par des moyens de détection supplémentaires (23, 24 ; 25a, 25b ; 26a, 26b) disposés dans le tunnel et/ou au niveau des entrées (2a, 2b) du tunnel (2), respectivement, pour mesurer la vitesse d'écoulement de l'air dans le tunnel (2), la différence de pression atmosphérique entre les entrées (2a, 2b) et le volume de trafic et la vitesse de déplacement des véhicules passant à travers le tunnel (2) ; en ce que dans les moyens de traitement (30), le volume de trafic à long terme est calculé sur la base des valeurs détectées par les détecteurs de volume de trafic (26a, 26b ; 27a, 27b) prévus au niveau et/ou à proximité des entrées (2a, 2b) du tunnel (2) pour commander la soufflerie d'évacuation (3) et les ventilateurs à jet (4, 5) ; et en ce que les moyens de traitement (30) sont dotés d'une unité de correction de débit (32) pour fournir les valeurs finales de régulation de la soufflerie d'évacuation (3) en fonction des valeurs détectées par les moyens de détection de pollution d'air (21, 22) et les détecteurs de volume de trafic (26a, 26b ; 27a, 27b), sur le court terme.

2. Dispositif de régulation selon la revendication 1, caractérisé en ce qu'une partie (33, 35) des moyens de traitement (30) traitent les valeurs physiques détectées par les moyens de détection supplémentaires (23, 24 ; 25a, 25b ; 26a, 26b) pour commander les ventilateurs à jet (4, 5) de façon telle qu'une circulation d'air frais soit maintenue dans le tunnel (2) à une vitesse d'écoulement appropriée depuis les deux entrées (2a, 2b) vers le puits de ventilation (1).

3. Dispositif de régulation selon la revendication 1 ou 2, caractérisé par des collecteurs de poussière électrique (61, 62) prévus à l'intérieur du tunnel (2) de chaque côté du puits de ventilation (1) pour collecter et éliminer la poussière du tunnel, les collecteurs de poussière électriques (61, 62) étant commandés en association avec la soufflerie d'évacuation (3) par l'unité de correction de débit (32).

4. Dispositif de régulation selon la revendication 1 ou 2, dans lequel lesdits moyens de traitement (30) comprennent : une unité logique de base (31) qui calcule séquentiellement une estimation du volume de trafic à long terme, un degré de pollution d'air à l'intérieur du tunnel (2), une demande en ventilation et une valeur d'allocation de débit sur la base des valeurs physiques détectées par les détecteurs de volume de trafic (26a, 26b ; 27a, 27b) pour déterminer une vitesse d'écoulement de référence, une demande en ventilation de référence et un nombre de référence de ventilateurs à jet (4, 5) à actionner ;

une unité de correction de débit (32) qui calcule une estimation du volume de trafic à court terme pour une régulation rétroactive du système de ventilation de tunnel sur la base des valeurs détectées par les détecteurs de trafic (26a, 26b ; 27a, 27b) et un degré de pollution d'air pour la régulation rétroactive du système de ventilation de tunnels sur la base d'un degré de pollution d'air détecté par le détecteur de degré de pollution d'air (21, 22), et qui additionne l'estimation de volume de trafic à court terme et le degré de pollution d'air pour établir un débit réglé de la soufflerie d'évacuation (3) ; et

une unité de régulation de vitesse d'écoulement (33) qui calcule l'équilibre de pression dans le tunnel (2) sur la base d'une vitesse d'écoulement détectée par les détecteurs de vitesse d'écoulement (23, 24) des moyens de détection, d'un volume de trafic détecté par les détecteurs de volume de trafic (26a,26b ; 27a, 27b) et de la vitesse d'écoulement de référence, qui calcule une vitesse d'écoulement pour la régulation rétroactive du système de ventilation du tunnel sur la base de la vitesse d'écoulement à l'intérieur du tunnel (2) détectée par les détecteurs de vitesse d'écoulement (23, 24) et de la vitesse d'écoulement de référence à la sortie de l'unité logique de base (31), et qui additionne les valeurs calculées et la vitesse d'écoulement de référence pour établir une vitesse d'écoulement réglée pour commander le fonctionnement des ventilateurs à jet (4, 5).

Patentansprüche

1. Steuereinrichtung für ein Tunnelbelüftungssystem zum Belüften eines Tunnels (2), der einen Ventilationsschacht (1) etwa in der Mitte des Tunnels, einen Absaugventilator (3) innerhalb des Ventilationsschachtes (1) und frei blasende Ventilatoren (4, 5) innerhalb des Tunnels (2) aufweist;
mit Detektoren (21, 22) zum Erfassen verschiedener physikalischer Werte, die den Grad der

Luftverunreinigungen in dem Tunnel (2) wiedergeben; und mit einem Prozessor (30) zur Verarbeitung der durch die Detektoren (21, 22) erfaßten physikalischen Werte, um den Betrieb und den Durchsatz des Absaugventilators (3) und der frei blasenden Ventilatoren (4, 5) zu steuern;
dadurch gekennzeichnet, daß weitere Detektoren (23, 24; 25a, 25b; 26a, 26b) innerhalb des Tunnels und/oder an den Portalen (2a, 2b) des Tunnels (2) vorgesehen sind, um die Luftströmungsgeschwindigkeit innerhalb des Tunnels (2) die Differenz im atmosphärischen Druck zwischen den Portalen (2a, 2b) sowie das Verkehrsaufkommen und die Fahrgeschwindigkeit von durch den Tunnel (2) fahrenden Fahrzeugen zu messen;
daß in dem Prozessor (30) das Langzeit-Verkehrsaufkommen auf der Basis der durch die Verkehrsaufkommens-Detektoren (26a, 26b; 27a, 27b) am und/oder in der Nähe der Portale (2a, 2b) des Tunnels (2) berechnet wird, um den Absaugventilator (3) und die frei blasenden Ventilatoren (4, 5) zu steuern; und daß der Prozessor (30) mit einer Strömungs-Korrektureinheit (32) ausgestattet ist, mit der eine Feinsteuerung des Absaugventilators (3) abhängig von den Meßwerten des Lufverunreinigungs-Detektors (21, 22) und der Verkehrsaufkommens-Detektoren (26a, 26b; 27a, 27b) auf einer Kurzzeitbasis erfolgt.

2. Steuereinrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß ein Teil (33, 35) des Prozessors (30) die durch die weiteren Detektoren (23, 24; 25a, 25b; 26a, 26b) überwachten physikalischen Werte verarbeitet und die frei blasenden Ventilatoren (4, 5) in einer solchen Weise steuert, daß von beiden Portalen (2a, 2b) in Richtung auf den Ventilationsschacht (1) ein Frischluftstrom in dem Tunnel (2) mit bestimmter Strömungsgeschwindigkeit aufrechterhalten wird.

3. Steuereinrichtung nach Anspruch 1 oder 2,
dadurch gekennzeichnet, daß innerhalb des Tunnels (2) zu beiden Seiten des Ventilationsschachtes (1) elektrische Staubkollektoren (61, 62) vorgesehen sind, um aus dem Tunnel Staub zu sammeln und zu entfernen, und daß die elektrischen Staubkollektoren (61, 62) zusammen mit dem Absaugventilator (3) durch die Strömungs-Korrektureinheit (32) gesteuert werden.

4. Steuereinrichtung nach Anspruch 1 oder 2,
dadurch gekennzeichnet, daß der Prozessor (30) folgende Einheiten enthält:

eine Grundlogikeinheit (31), die sequentiell eine Langzeit-Verkehrsaufkommens-Schätzung, die Luftverschmutzung innerhalb des Tunnels (2), eine Ventilationsanforderung und einen Strömungsmengenwert auf der Basis der durch die Verkehrsaufkommens-Detektoren (26a, 26b; 27a, 27b) erfaßten physikalischen Werte berechnet, um Referenzwerte für die Strömungsgeschwindigkeit und die Ventilationsanforderung sowie eine Referenzanzahl der einzuschaltenden frei blasenden Ventilatoren zu ermitteln;
die Strömungs-Korrektureinheit (32), die auf der Basis der durch die Verkehrsaufkommens-Detektoren (26a, 26b; 27a, 27b) gemessenen Werte auf Kurzzeitbasis eine Verkehrsaufkommens-Schätzung zwecks Rückkopplungs-Regelung des Tunnelbelüftungssystems berechnet, die auf der Basis der durch den Luftverunreinigungs-Detektor (21, 22) erfaßten Luftverunreinigung den Grad der Luftverunreinigung zwecks Rückkopplungs-Regelung des Tunnelbelüftungssystems berechnet, und die Werte der Verkehrsaufkommens-Schätzung und des Grades der Luftverunreinigung addiert, um die Strömungsmenge des Absaugventilators (3) zu steuern; und
eine Strömungsgeschwindigkeits-Steuereinheit (33), die die Druckverhältnisse innerhalb des Tunnels (2) auf der Basis der durch die Strömungsgeschwindigkeits-Detektoren (23, 24) erfaßten Strömungsgeschwindigkeit und des durch die Verkehrsaufkommens-Detektoren (26a, 26b; 27a, 27b) erfaßten Verkehrsaufkommens berechnet, eine Strömungsgeschwindigkeit für die Rückkopplungs-Regelung des Tunnelbelüftungssystems auf der Basis der durch die Strömungs-geschwindigkeits-Detektoren (23, 24) erfaßten Strömungsgeschwindigkeit innerhalb des Tunnels (2) und der Referenz-Strömungsgeschwindigkeit entsprechend dem Ausgangssignal der Grundlogikeinheit (31) berechnet, und die beiden berechneten Werte und die Referenz-Strömungsgeschwindigkeit addiert, um einen Steuerwert für den Betrieb der frei blasenden Ventilatoren (4, 5) zu erhalten.

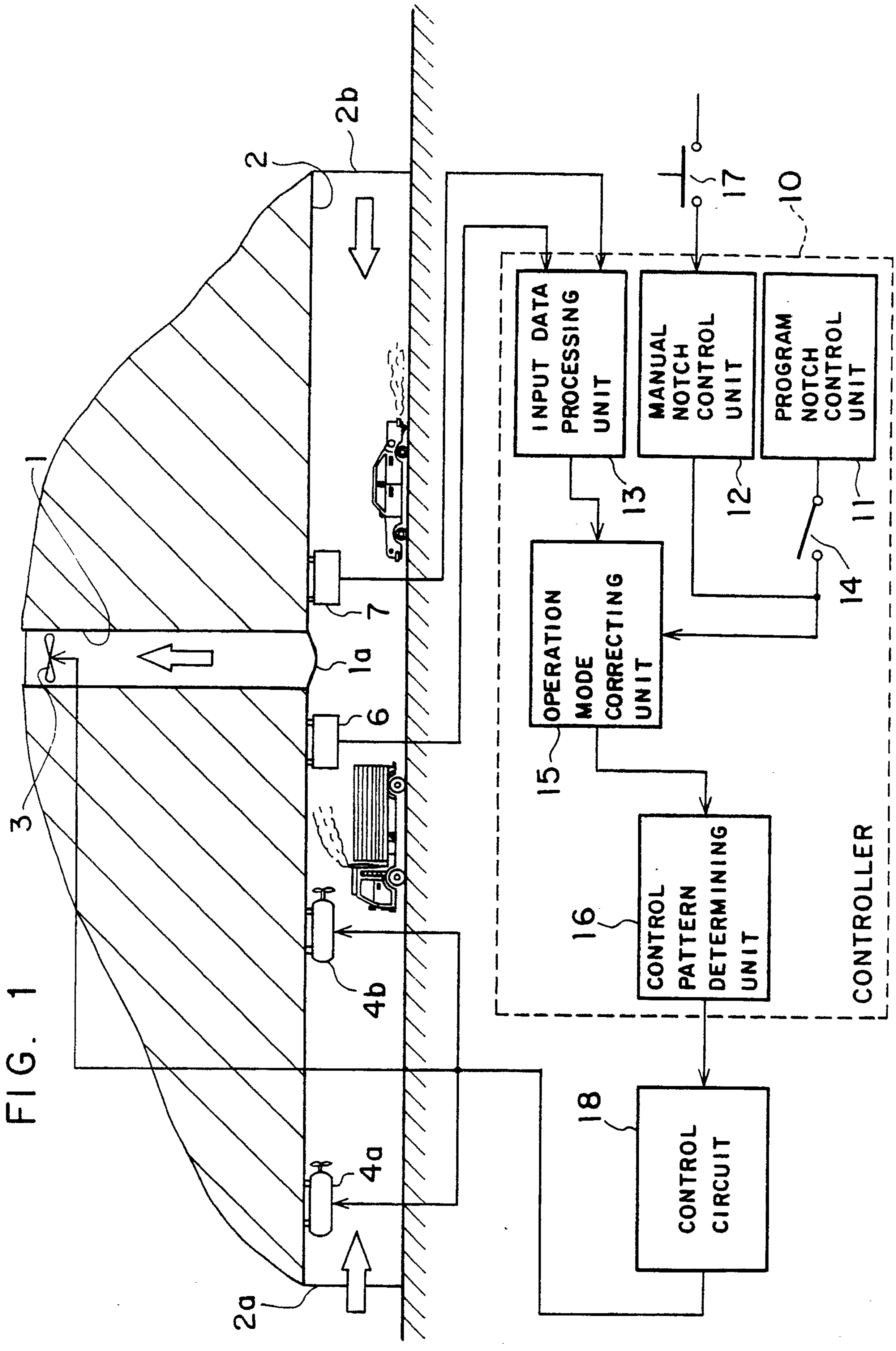


FIG. 1
INPUT DATA PROCESSING UNIT
MANUAL NOTCH CONTROL UNIT
PROGRAM NOTCH CONTROL UNIT
OPERATION MODE CORRECTING UNIT
CONTROL PATTERN DETERMINING UNIT
CONTROLLER
CONTROL CIRCUIT
1
1a
2
2a
2b
3
4a
4b
6
7
10
11
12
13
14
15
16
17
18

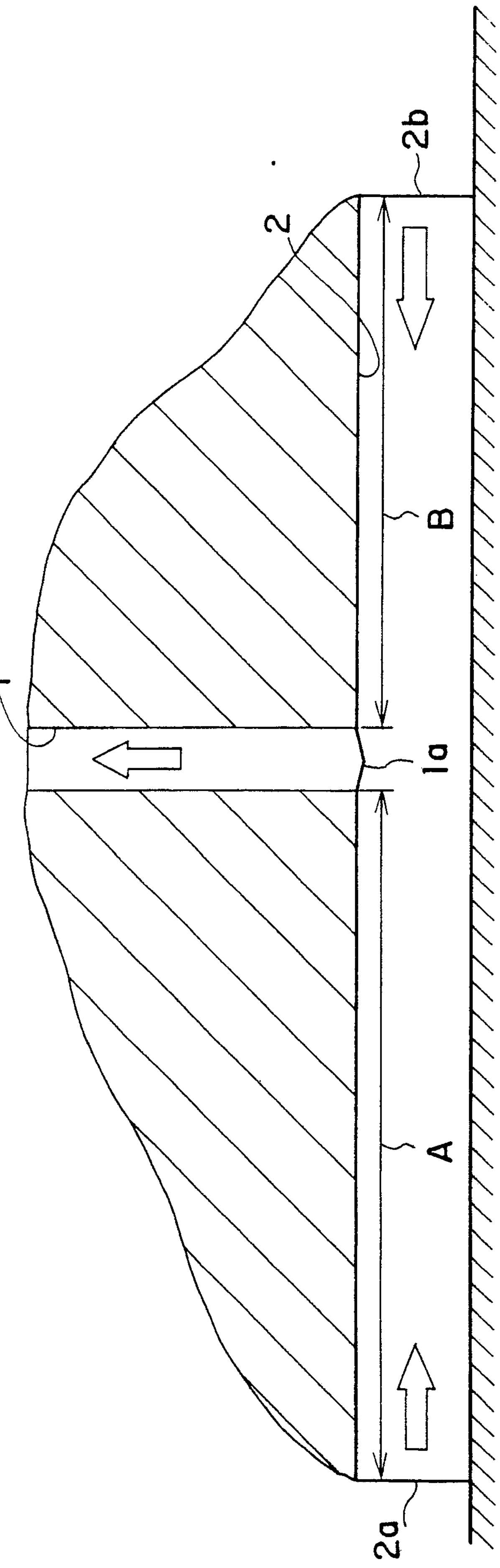

2b
2
B
1
1a
A
2a

FIG. 2A

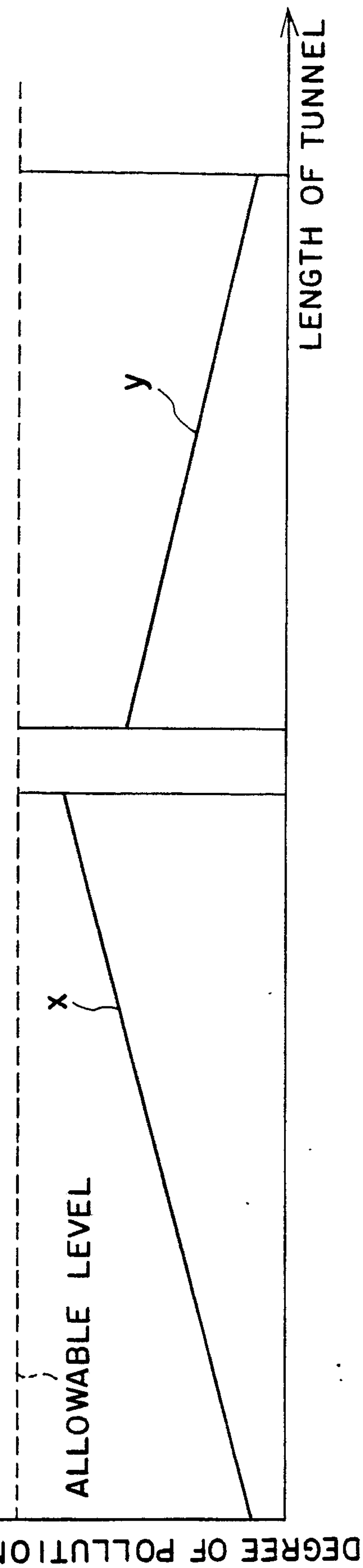

LENGTH OF TUNNEL
y
x
ALLOWABLE LEVEL
DEGREE OF POLLUTION

FIG. 2B

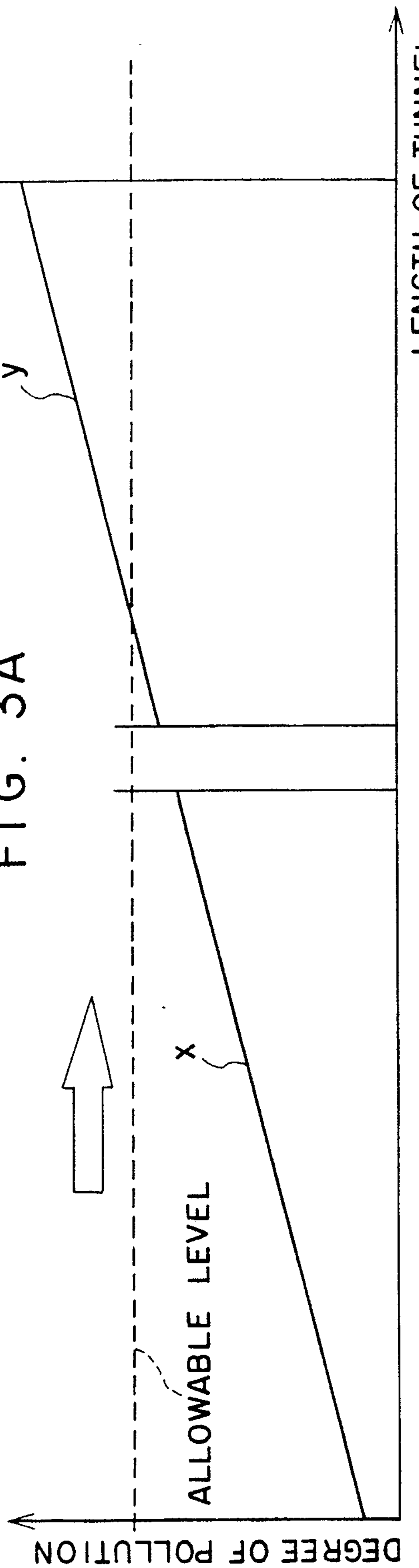

LENGTH OF TUNNEL
DEGREE OF POLLUTION
ALLOWABLE LEVEL
x
y

FIG. 3A

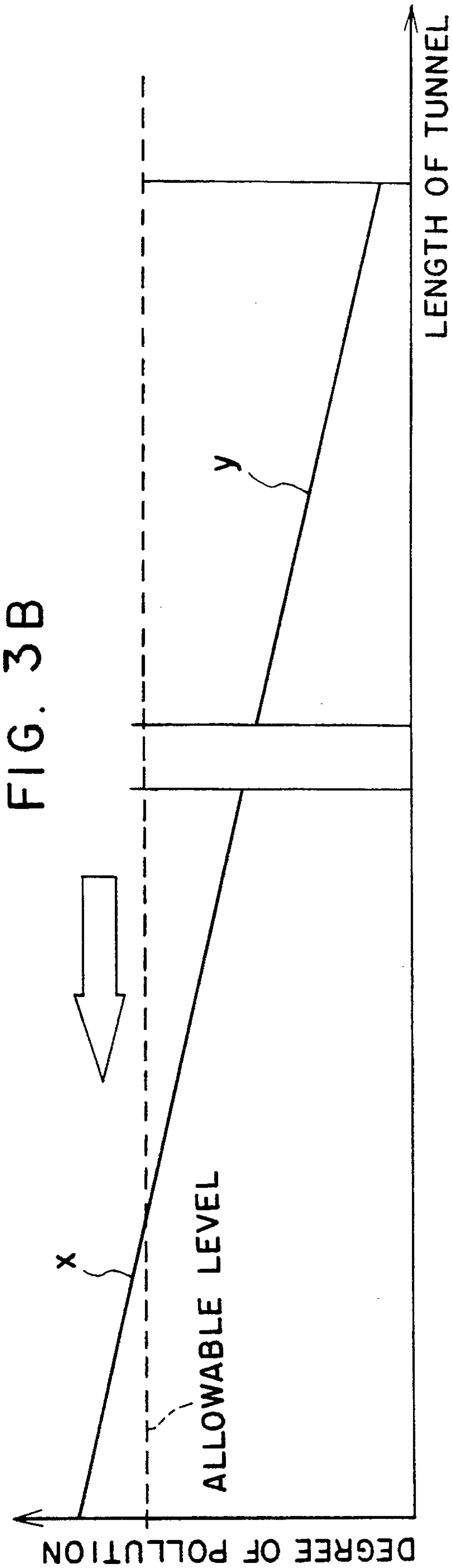
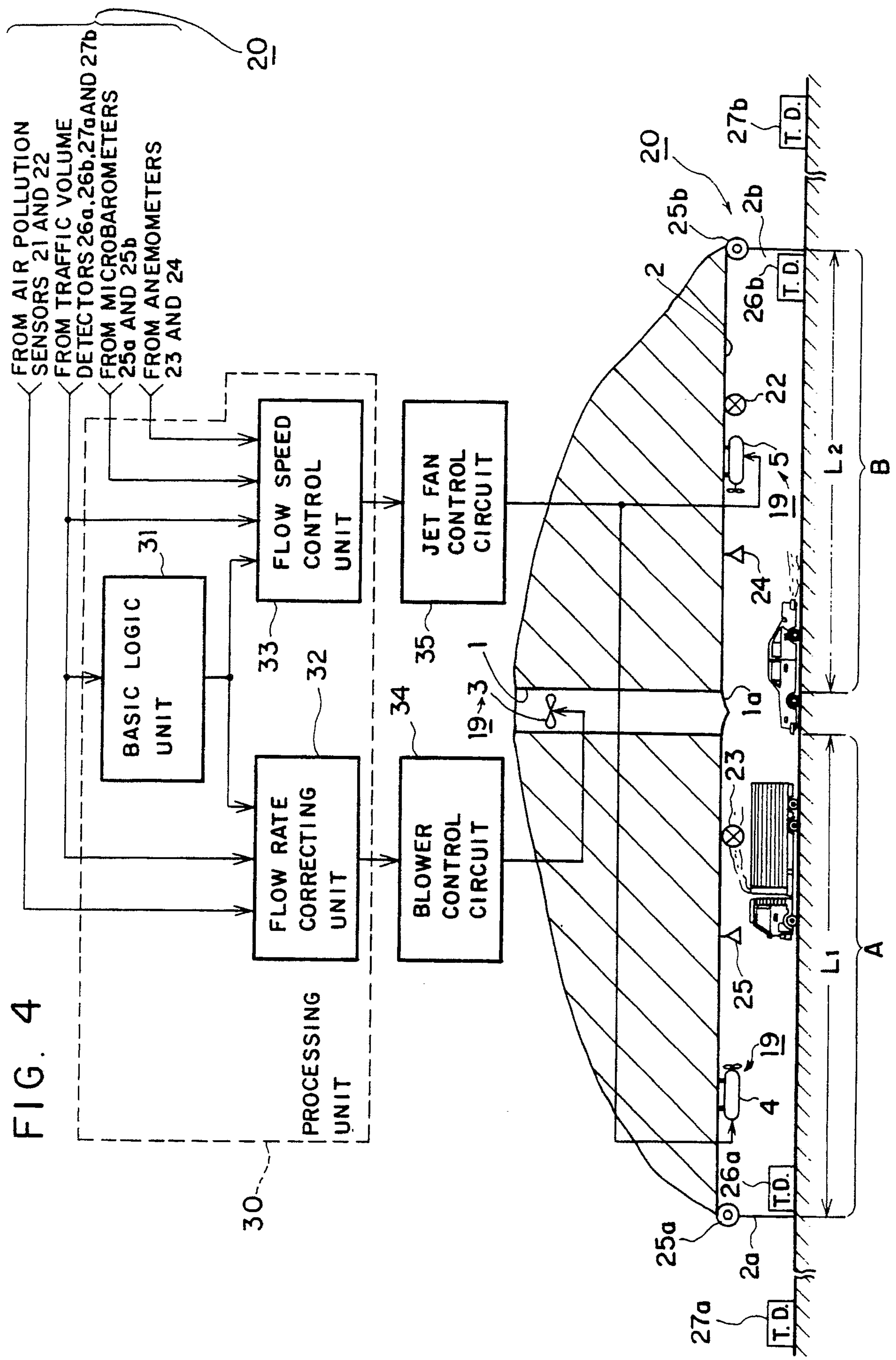

LENGTH OF TUNNEL
DEGREE OF POLLUTION
ALLOWABLE LEVEL
x
y

FIG. 3B

FIG. 4


FROM AIR POLLUTION SENSORS 21 AND 22
FROM TRAFFIC VOLUME DETECTORS 26a,26b,27a AND 27b
FROM MICROBAROMETERS 25a AND 25b
FROM ANEMOMETERS 23 AND 24
20
BASIC LOGIC UNIT
31
FLOW SPEED CONTROL UNIT
33
FLOW RATE CORRECTING UNIT
32
PROCESSING UNIT
30
JET FAN CONTROL CIRCUIT
35
BLOWER CONTROL CIRCUIT
34
19
3
1
1a
2
2a
2b
4
5
19
22
23
24
25
25a
25b
26a
26b
27a
27b
T.D.
L1
L2
A
B

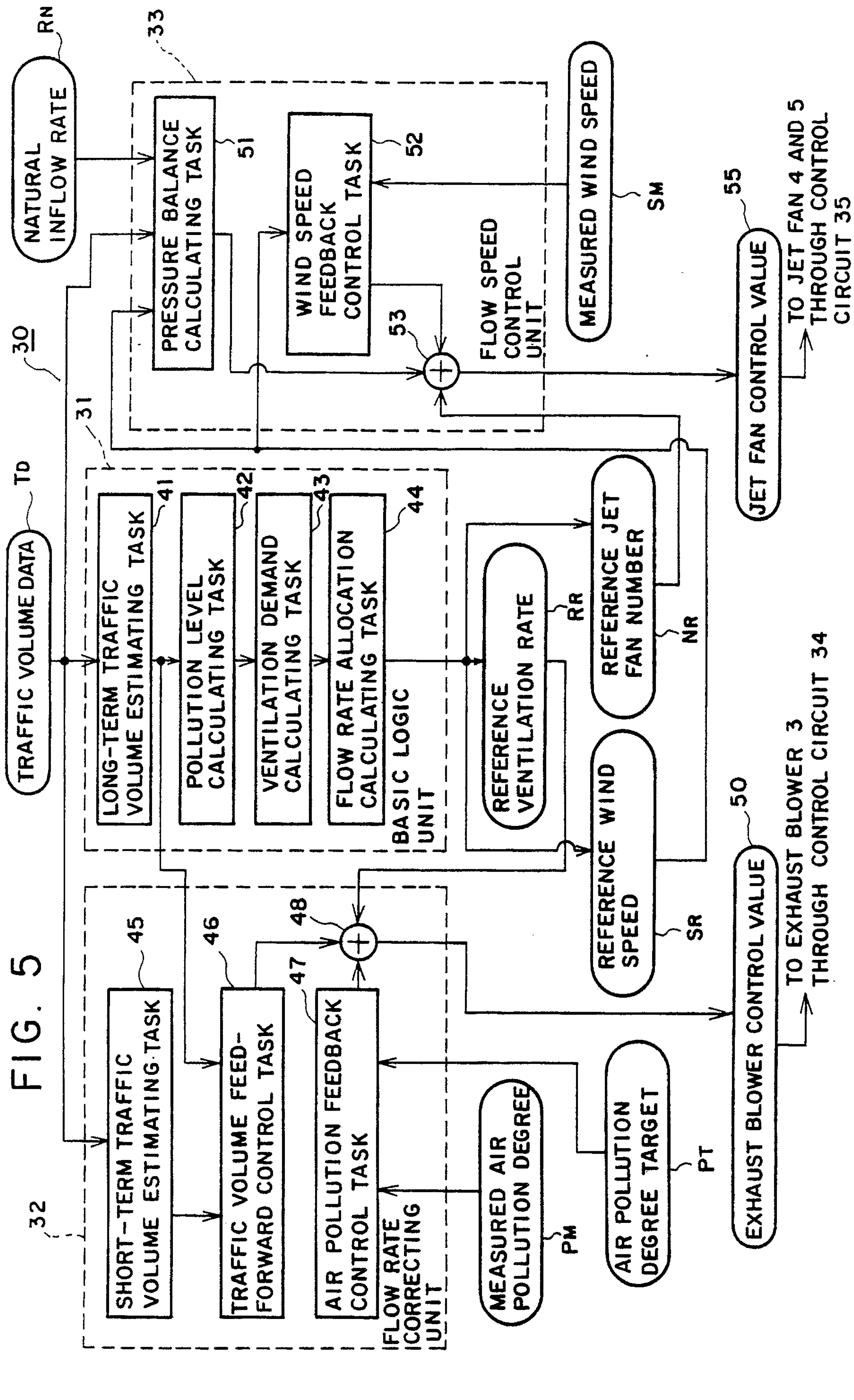

NATURAL INFLOW RATE
RN
33
PRESSURE BALANCE CALCULATING TASK
51
WIND SPEED FEEDBACK CONTROL TASK
52
MEASURED WIND SPEED
SM
53
FLOW SPEED CONTROL UNIT
55
JET FAN CONTROL VALUE
TO JET FAN 4 AND 5 THROUGH CONTROL CIRCUIT 35
30
31
TRAFFIC VOLUME DATA
TD
LONG-TERM TRAFFIC VOLUME ESTIMATING TASK
41
POLLUTION LEVEL CALCULATING TASK
42
VENTILATION DEMAND CALCULATING TASK
43
FLOW RATE ALLOCATION CALCULATING TASK
44
BASIC LOGIC UNIT
REFERENCE VENTILATION RATE
RR
REFERENCE JET FAN NUMBER
NR
REFERENCE WIND SPEED
SR
50
EXHAUST BLOWER CONTROL VALUE
TO EXHAUST BLOWER 3 THROUGH CONTROL CIRCUIT 34
32
SHORT-TERM TRAFFIC VOLUME ESTIMATING TASK
45
TRAFFIC VOLUME FEED-FORWARD CONTROL TASK
46
AIR POLLUTION FEEDBACK CONTROL TASK
47
48
FLOW RATE CORRECTING UNIT
MEASURED AIR POLLUTION DEGREE
PM
AIR POLLUTION DEGREE TARGET
PT

FIG. 5

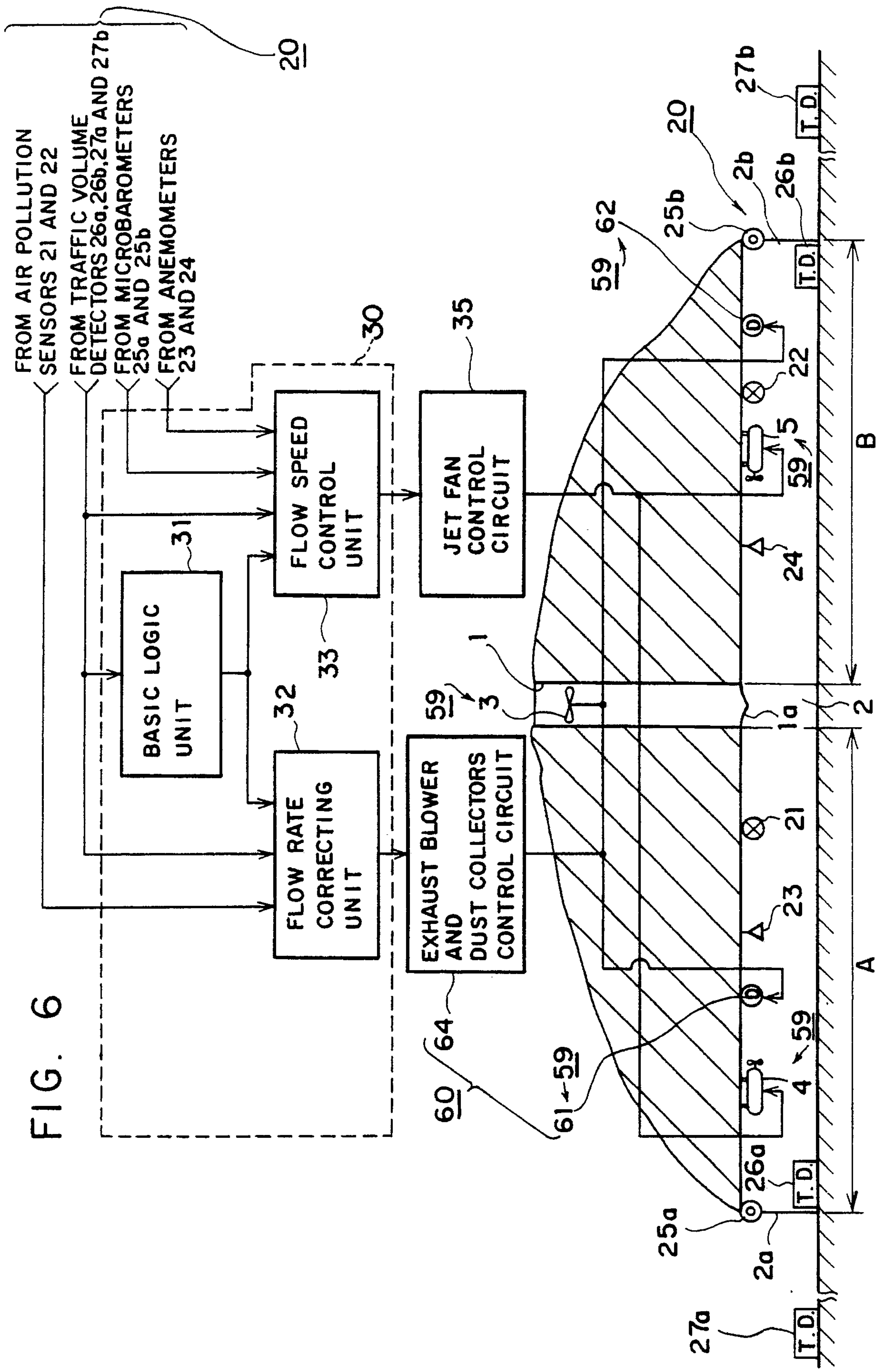

FROM AIR POLLUTION SENSORS 21 AND 22
FROM TRAFFIC VOLUME DETECTORS 26a,26b,27a AND 27b
FROM MICROBAROMETERS 25a AND 25b
FROM ANEMOMETERS 23 AND 24
20
30
31
BASIC LOGIC UNIT
FLOW SPEED CONTROL UNIT
33
FLOW RATE CORRECTING UNIT
32
JET FAN CONTROL CIRCUIT
35
EXHAUST BLOWER AND DUST COLLECTORS CONTROL CIRCUIT
64
60
61
59
62
1
1a
2
3
4
5
21
22
23
24
25a
25b
26a
26b
27a
27b
2a
2b
T.D.
A
B

FIG. 6