LECTURE – 2

THE CONTENTS OF THIS LECTURE ARE AS FOLLOWS:

1.0 DISTRICT SYSTEM

1.1 U-Tube Ventilation System

1.2 Through-Flow Ventilation System

2.0 APPLICATION OF U-TUBE TYPE VENTILATION SYSTEM

2.1 Application of U-Tube Type Ventilation System in Bord and Pillar Method of Mining

2.2 Application of U-Tube Type Ventilation System in Longwall Mining

2.2.1 Advancing longwall panel

2.2.2 Retreating longwall panel

2.2.3 W- system

REFERENCES

1.0 DISTRICT SYSTEM

In underground mines, excavation or production goes on in different panels, districts or workings. Now the question arises, how these panels, districts or workings are ventilated? How to allow a part of coming main intake air to ventilate a district and after ventilation, make the air to go to the main return.

The geology of the area, type of deposit and method of mining in case of coal plays a crucial role in determining the design of ventilation system for ventilating different panels or districts. There can be different configurations for ventilating a district of different mines. However, the different types of configurations that are developed can be put under two broad categories. They are:

a. U-TUBE VENTILATION SYSTEM
b. THROUGH - FLOW VENTILATION SYSTEM

In some cases, the configuration may be a combination of both of these two systems. These configurations are dependent on whether the provision for intake air is through a single entry or through multi entry. To know the different designs of ventilation systems in a district, their merits and demerits, cost involved for ventilation, quantity of air required etc., we must know about the above two basic designs and their principles. Let us have a look at them.

1.1 U-tube Ventilation System

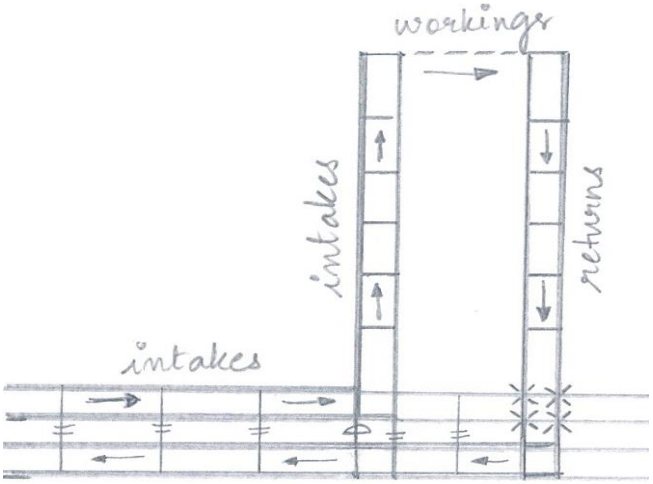

Fig.1 Typical layout of U-tube ventilation system (after McPherson, 1993)

Fig. 1 gives an idea about the flow of air in the U-tube type of ventilation system. Here, we can see that the main intakes and returns run adjacent to each other. To ensure proper ventilation at different workings, a number of stoppings and doors are installed, thus separating the intakes and the returns. The air from main intake goes to the face or working and after ventilating comes to the main return. An air crossing has to be provided as intake and return airways have to cross each other without mixing.

1.2 Through – flow Ventilation System

Let us have a look at a typical layout of this system which is shown in Fig. 2.

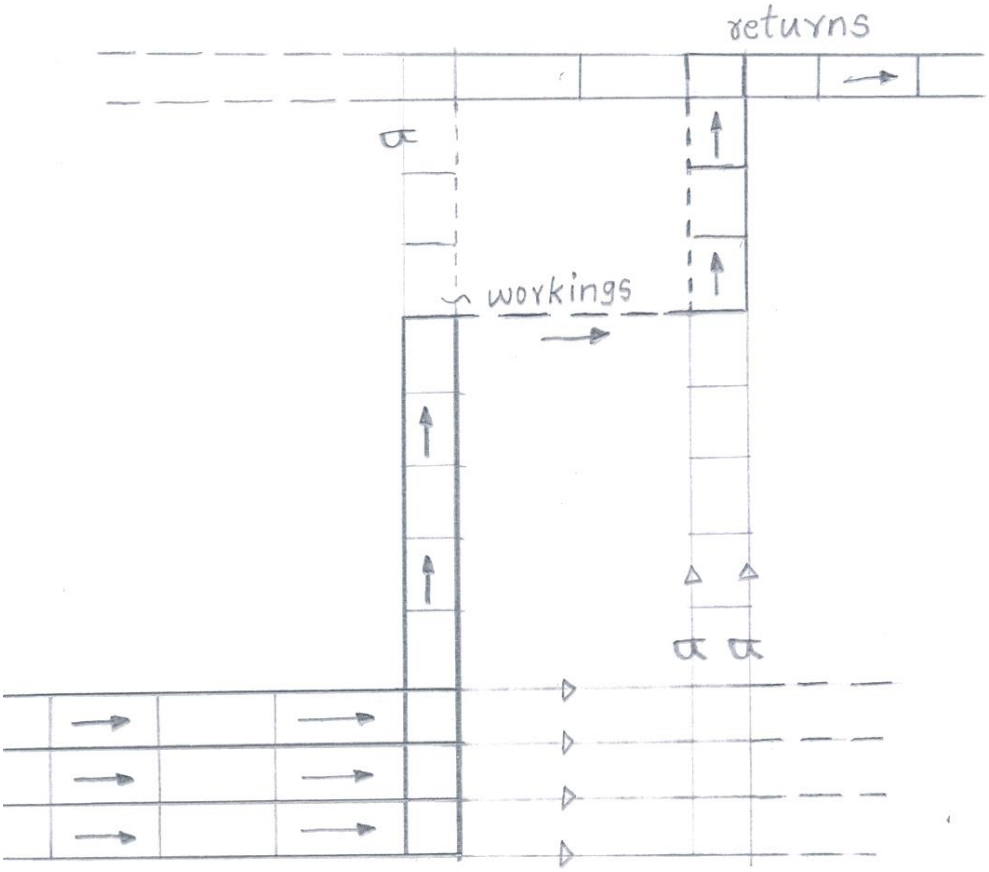

Fig. 2 Typical layout for a through-flow system (after McPherson, 1993)

Looking at the diagram shown in Fig. 2, can you make out the difference between U-tube system and through-flow system? Which of the systems mentioned above will be more effective in terms of efficiency, operation and construction? Let us analyze it.

We can see that working or district in case of through-flow system is in between the main intake and the main return. Thus, working separates them geographically or physically. The air from main intake goes to the working, ventilates the working and travels to the main return. We can see that air is supplied in one working through two or more intakes running from the primary intake. Regulators, may be passive or active, are used for proper maintenance of quantity in particular districts. Apart from the above, some of the other differences between the two systems are:

The adjacent airways are either all intakes or all returns as opposed to that of U-tube system where intake and return are running adjacent.
There may be fewer stoppings, doors and crossings in case of through-flow system whereas in case of U-tube type of ventilation system, we need more number of the above mentioned ventilation structures. It also follows that the leakage paths in case of through-flow system of ventilation will be lesser due to reduced number of different ventilation structures.

Now, the question arises which one of the two is better? The through-flow system has advantage over U-tube type with respect to lower leakage as well as lower resistance. Resistance in through-flow is reduced because of parallel connection of airways. It is a well known fact that the equivalent resistance of parallel connection is always lower than that of series connected airways. Thus, pressure drop will be lower in case of through-flow system of ventilation. Therefore, the total quantity of air available for ventilation will be higher in case of through-flow system of ventilation for a particular fan (developing a particular pressure) as the equivalent resistance has reduced significantly. Added to this is the benefit of lower leakage which is achieved in through-flow system of ventilation because of which, the total quantity of air supplied to the workings will be higher. Because of this, there is reduction in the operating cost of ventilation. On the other hand, this design has its limitation that it cannot be applied for ventilating pilot workings (e.g., blind openings) advancing into an area that has not been mined. It is the U-tube ventilation system which is generally advisable for room and pillar method and advancing longwall method. Through–flow system finds application in metal mines and retreating longwall methods.

We shall see the application of the two systems in detail. We shall also separately discuss their application in room and pillar method and longwall method of mining.

2.0 APPLICATION OF U-TUBE TYPE VENTILATION SYSTEM

2.1 Application of U-tube Type Ventilation System in Bord and Pillar Method of Mining

The design of ventilation system in bord and pillar method uses the principle of U-tube system. However, here too we can find variation on the basis of air flowing pattern. In one case, we design the ventilation circuit such that intake and return are adjacent. In another case, two or more intakes are made adjacent and after ventilation the air has to flow through two or more returns and these returns are also made adjacent. In other words, we can say that in first case, air flows in opposite direction in adjacent openings and in the second case, it flows in the same direction in adjacent openings. The first one is called bidirectional flow and second one is called unidirectional flow. Let us explain them through suitable diagrams as given in Fig. 3.

Fig. 3 shows bord and pillar method of mining in development stage. We can see that there are five roadways namely A, B, C, D and E and in the central roadway i.e., C, belt conveyor is there. Intake air flows through roadways A and B. Note that A and B are adjacent. Hence we can easily say that it is an example of unidirectional flow system. Air from A and B goes to the face and then comes back through roadways D and E. Thus D and E serve as return roadways. We can notice the use of permanent and temporary stoppings/brattice curtains in order to prevent the short-circuiting of intake and return air. Line brattice has been used in the development heading for ventilating the face. We shall discuss about line brattice in detail latter.

Now let us discuss about bidirectional flow system. We shall first try to understand the basic difference between the unidirectional and bidirectional flow system with the help of a typical layout.

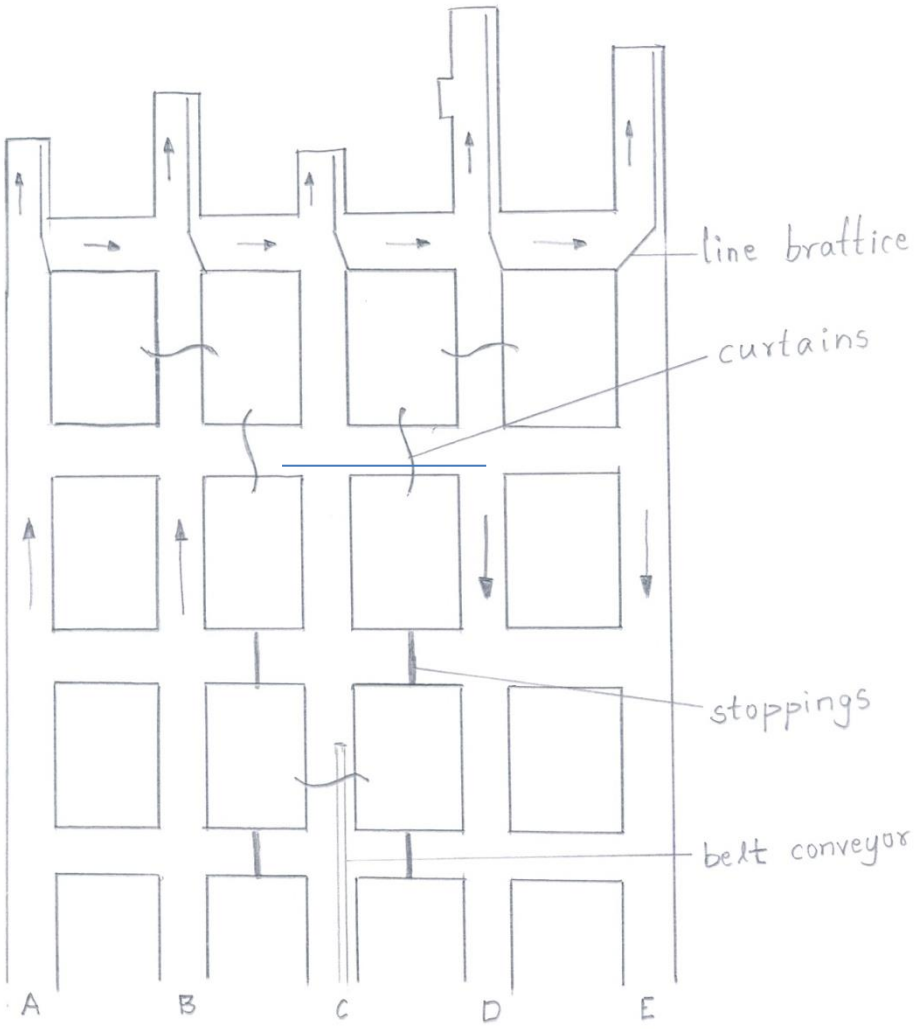

Fig. 3 Typical layout of unidirectional flow system

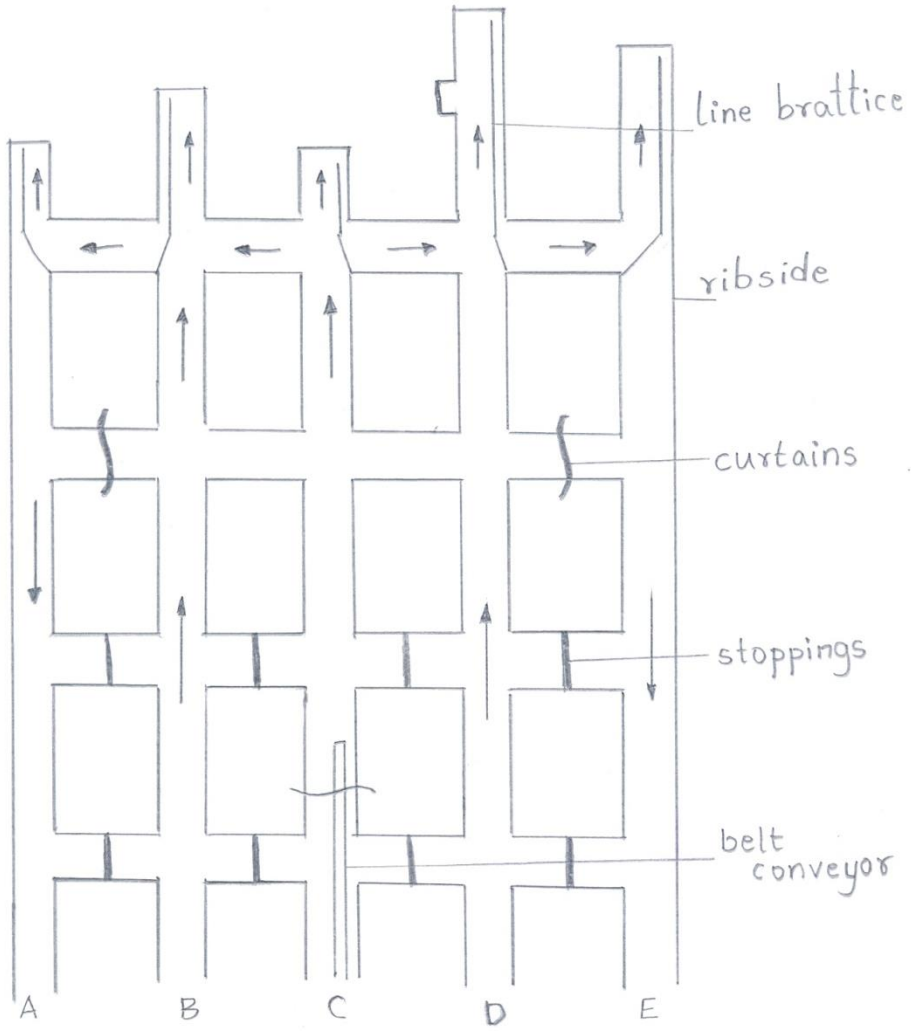

Fig. 4 Typical layout of a bidirectional flow system

Fig. 4 shows that in adjacent roadways air flows in the opposite direction. For example if we try to trace the path of air entering through B, we can say that air entering from B goes to different headings and after ventilation travels back via roadway, A. Also note that A and B are adjacent. Similar observation can be made for roadways D and E. In this figure, belt conveyor is occupying the central roadway, C. We can also notice increased number of permanent and temporary stoppings in this system compared to the unidirectional flow system.

Now, let us compare of the two types of flow systems. This is given in detail in Table 1.

Table 1 Comparison of unidirectional and bidirectional flow system

Parameters	Unidirectional flow system	Bidirectional flow system
Splitting of airway	No splitting of airway at all. Here, the incoming air from every opening has to pass through the whole panel through different headings one by one. Thus, this can be thought of as a series connection. Let me tell you at this stage that, in series connection, resistances of different airways are added up and equivalent resistance is given as: $R_{eq}= R_1 + R_2 + R_3$……..	Splitting of airway takes place nearly at the end of the panel. Further, air flowing from one roadway has to ventilate only half of the panel. This splitting can be thought of as parallel connection and R_{eq} is given by the relation: $\frac{1}{\sqrt{R_{eq}}} = \frac{1}{\sqrt{R_1}} + \frac{1}{\sqrt{R_2}} + \frac{1}{\sqrt{R_3}}$ ---- Lesser resistance implies lesser friction and lower ventilation cost compared to the unidirectional system of flow.
Quality management of air or methane addition in the course of travel	The sides of the panel, called rib sides are the major source of methane emission. We can see that they lie at outer end of the panel (Refer Fig.3). We know that one of the intake airway passes along the outer end or ribside. This will cause more addition of methane in the course of its travel in the intake airway thereby increasing the concentration of methane at the face.	In case of gassy mines, it becomes necessary to have return airway on the outer end or ribside. Because of this, methane will be added to return air which is not a matter of concern. From Fig. 4, we can see that in bidirectional flow, returns are on the outer side of the panel and hence methane is mainly added to the return air.
Leakage in the path	Since adjacent openings are either all intakes or returns, leakage roots are	Leakage roots are large in numbers. The situation

	greatly reduced and hence it increases the volumetric efficiency of the air.	is worsened when the volumetric efficiency falls to a level that there is inadequate supply of air. This, we can solve by increasing the pressure.
Application	Mines with lower gas emissions When the bords are driven from one side to the other side in a panel.	Mines with higher gas emissions When bords are driven on both sides of the panel simultaneously.

Before I proceed to the next topic let me tell you that unidirectional flow system is also called U-tube system or single split and bidirectional is also called W-system or double split. However, the principle used in them is basically that of U-tube system.

2.2 Application of U-tube Ventilation System in Longwall Mining

Let us now discuss about the ventilation system in longwall method of mining. Before going to discuss about the ventilation system in longwall method of mining, it is better to know, what the different longwall mining methods are.

Longwall mining can be of two types- retreating and advancing. In retreating longwall, intakes and returns are developed prior to the extraction phase. However in advancing longwall, development of intakes and returns and extraction go simultaneously. Also in advancing longwall, gob is separated from intake or return by constructing packwall. This is done for two reasons:-

i. To lower the quantity of air needed.
ii. To lower leakage of gases from gob areas.

Now, let us see the application of U-tube system in longwall method of mining.

2.2.1 Advancing longwall panel

Look at the diagram shown in Fig. 5

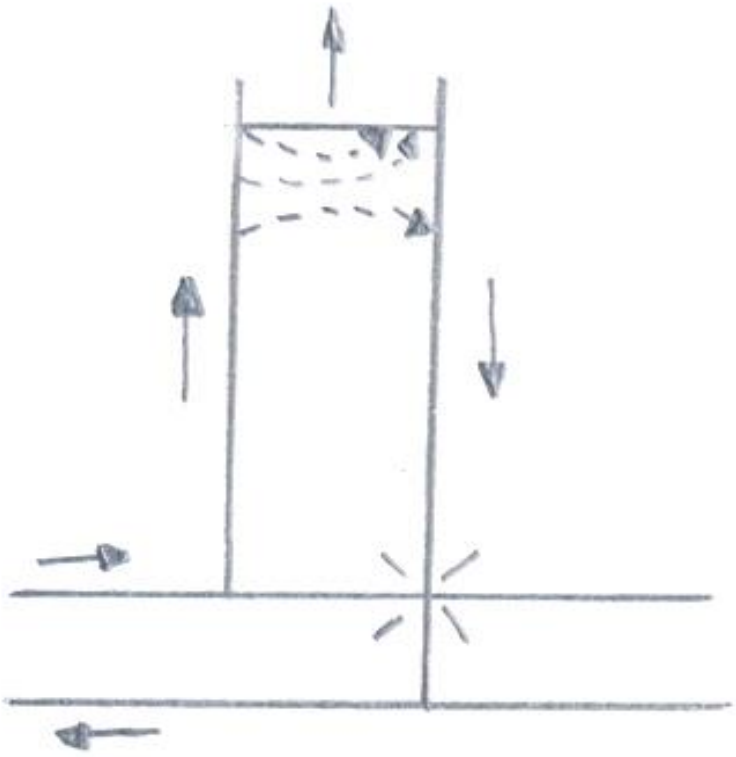

Fig. 5 Single entry advancing longwall system (after McPherson, 1993)

Fig. 5 depicts the layout of single entry advancing longwall system. The dotted line in this figure shows gas emission. We can see that primary or the main intake and main return are running adjacent to each other. Thus, it uses the principle of U-tube ventilation system. Two types of problems occur by using this principle of ventilation:

- Leakage of air between intake and gob area. Though pack walls separate them, but leakage is not completely stopped. This can lead to gob fire. This happens as leakage of air ensures continuous availability of oxygen in the gob area thereby leading to spontaneous heating of coal.

- Gases from gob flush at the face. These may be methane or other methane air mixture. They are shown as dotted line in Fig. 5. We see that concentration of these gases increases at the face towards the return side.

2.2.2 Retreating longwall panel

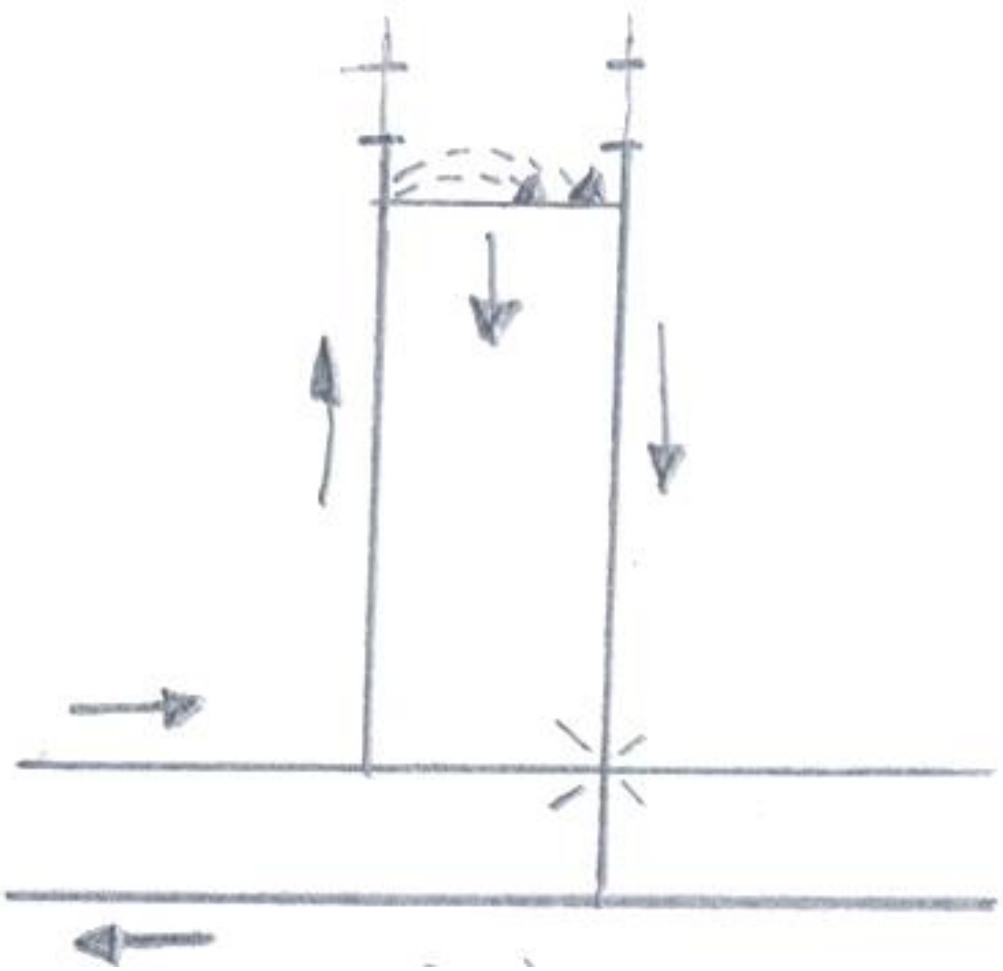

Fig. 6 Single entry retreating longwall system (after McPherson, 1993)

Fig. 6 shows a single entry retreating longwall system. It differs from the previous one, with respect to the position of gob and the working coal seam. Here, we are excavating coal from the end of panel and heading towards the start of the panel. In Fig. 6, we can see that intake or return does not have to pass along the gob except at the face unlike that of advancing longwall system. Therefore, construction of packwall is not required in this case. As air does not remain in contact with gob area for a longer time, the leakage problem is significantly reduced compared to that of advancing longwall system. Subsequently, chances of gob fire are greatly reduced in this system. However, the flushing of emitted gas at the face from gob exists.

2.2.3 W-system

This system works on the principle of U-tube ventilation system. The most important feature of this system is its applicability in both types of longwall method of mining ie. retreating as well as advancing. Let us look at Fig. 7.

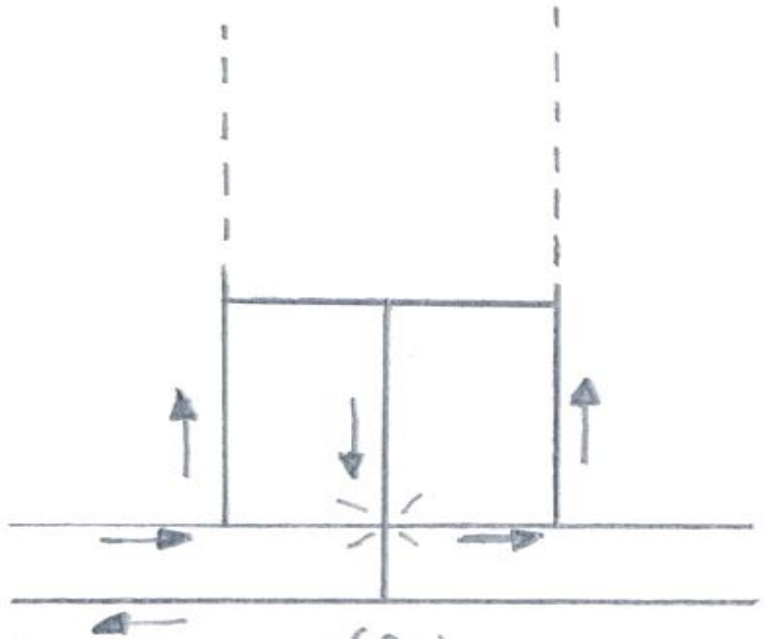

Fig. 7 Layout of W-system (after McPherson, 1993)

Fig. 7 itself suggests that it works on the principle of U-tube ventilation system. We can see that there are two intakes and one return. Regulators are provided for judicious use of air. We can also see that air entering from one intake has to cover only half of the face length for ventilation purpose. This may create confusion to the reader whether it works on U-tube principle or through-flow principle. But, we see that primary intake and return are running adjacent to each other. So, it is an example where U-tube principle is being applied. The most important advantage of this system is that it can be used for both advancing as well as retreating longwall panel.

Students are advised to look into the application of Through-flow ventilation system from some standard text book on Underground Ventilation like Subsurface Ventilation and Environmental Engineering authored by M. J. McPherson or some standard books on Underground Coal Mining.

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