(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 086 080**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 83300505.1

(51) Int. Cl.³: **B 61 B 13/10**

(22) Date of filing: 01.02.83

(30) Priority: 04.02.82 US 345699

(43) Date of publication of application:
17.08.83 Bulletin 83/33

(84) Designated Contracting States:
DE FR GB IT

(71) Applicant: Yen, James T.
1 Cypress Drive
Woodbury New York 11797(US)

(72) Inventor: Yen, James T.
1 Cypress Drive
Woodbury New York 11797(US)

(74) Representative: Wright, Peter David John et al,
R.G.C. Jenkins & Co. 12-15, Fetter Lane
London EC4A 1PL(GB)

(54) Tubular coal transport system.

(57) A tubular coal transport system wherein a continuous succession of individually-powered loaded cars travel through a tube from a coal source to a receiving terminal over an extended distance. Each wheeled car has a generally cylindrical form and includes a bottom trough in which electric motors are installed to drive the car wheels at a controlled rate, and a cover composed of two arcuate sections hinged to the trough and foldable therein to collapse the car when it is empty, thereby reducing the volume of the emptied car. When loaded, the cars travel from the coal source to the receiving terminal along a foward track mounted on the base of the tube adjacent one side wall thereof. When empty, the collapsed cars travel back to the coal source on a return track mounted on the opposite side wall of the tube, the cars being held in place by guide rails. The arrangement is such that the succession of loaded and empty cars travelling in opposing directions occupy substantially all available tube space.

EP 0 086 080 A2

TUBULAR COAL TRANSPORT SYSTEM

Background of Invention

This invention relates generally to coal transportation, and more particularly to a tubular coal transport system in which a continuous succession of small, individually-powered loaded cylindrical cars travel through a tube, the empty cars being returned in the same tube to the coal site in a collapsed state, the arrangement being such that the loaded and empty cars travelling in opposing directions occupy substantially all available space in the tube.

Coal usable as an energy source takes many forms. Thus anthracite, which is hard, compact and shiny black, ignites with some difficulty and burns with a smokeless blue flame. At present, electric power generating plants situated in or close to anthracite-producing regions are important users of such coal. The use of anthracite produced at mines remote from power plants is presently discouraged by the high cost of coal transport. Also available are low-volatile, medium volatile and high-volatile bituminous coal. The principal ranks of coal mines in major coal-producing states in the United States are set forth in bulletins published by the U.S. Bureau of Mines. Among the several states in which coal is mined are Colorado, New Mexico, Utah and Wyoming.

Currently, two main modes of transportation are used to transport coal mines in such non-industrial states as Utah and Wyoming for an extended distance from the mining site to ports or transfer points on the west coast or on the Great Lakes. These modes are unit-trains and slurry pipelines.

Because of the sharply rising cost of oil, energy plans for the future contemplate a marked increase in the rate of coal production. Thus in the case of western coal, it is expected that the production rate in future years will rise to a level above 200 million tons a year. Existing modes of coal transportation are ill-suited for handling such vastly increased amounts of coal. The limitations of unit-train and slurry pipeline coal transport systems will now be considered.

A conventional unit-train is composed of as many as one to two hundred coal cars which are linked together and drawn by one or more diesel or steam locomotives. Its length is such that it takes several minutes for a unit train to pass through a road crossing; and with a number of unit trains passing through in the course of a single day, these trains represent a serious interference in the daily life of communities which lie on the path of the railroad.

To avoid having coal-bearing trains pass through ground-level crossings, one may provide underground cuts or overpasses. But because of the considerable size and weight of unit-train locomotives, each of which weights more than 700 tons, the construction of suitable underground cuts or overpasses would be inordinately expensive. Moreover, railroad tracks, bridges and equipment in their present-day condition are notoriously dilapidated; hence the expenditures entailed to update railroads in order to handle heavy future coal demands would involve extraordinarily massive financial investments. These investments would necessarily be reflected in transport costs and result in a further step-up of the cost per ton of coal.

Coal may be transported over a considerable distance by solids pipelines. A solids pipeline, as distinct from a fluid pipeline, requires that the solid product to be transported be prepared for pipeline conveyance. Thus to convey coal by long distance solids pipelines, the largest particle size must be limited to that which can readily pass through commercially-available pipes and related equipment.

Unclean coal can be transported by pipeline, but the use of clean coal creates a slurry with a lower and more uniform friction-heat loss; it reduces pipe-wall wear and enlarges the system capacity. Hence the modern practice is to first clean the coal, then grind the clean coal to the proper particle size and size range distribution, and finally mix the particles with water in the prescribed concentration.

In a coal slurry pipeline system, one not only requires heavy-duty pumping stations at various points along the travel path as well as high-strength durable pipes, but at the receiving terminals the coal must be dewatered, use being made for this purpose of settling ponds. The coal slurry system, despite high installation, operating and maintenance costs, is usually feasible, especially when its costs are compared to unit-train transport costs, for medium distances.

In any slurry pipeline system for coal, water must be available at the transmitting end of the line in plentiful quantities, for the water used for the slurry is not returned to its point of origin but is discharged at the receiving end of the pipeline. A slurry system is therefore inappropriate to mining sites located in semi-arid regions or those such as Wyoming and Utah which lack adequate surface water supplies. In some instances, water can be obtained by drawing it by pumps from a deep underground water-bearing stratum of permeable rock or sand, yet it may be inadvisable to deplete this resource. The extration of water over a period of years from aquifers may lead to a significant shrinkage thereof, thereby lowering the ground water level, with possible disastrous consequences to regional agricultural operations.

The cost of transporting coal in a slurry pipeline 650 miles long in a system having a 10 million tons per year capacity has been estimated to be $21.4 per ton (see "Transportation Alternatives to the West Coast" - L.I. Kopeikin, Conference in Washington, D.C. on "Coal Imports" - sponsored by the Energy Bureau - December 1980). In contrast thereto, conventional-unit train transportation over the same distance is estimated to cost $35.60 per ton.

However, even assuming the availability of an adequate water supply, the economic advantages of a slurry pipeline over a unit-train coal transport system becomes less attractive when a closer look is taken at the nature of a slurry pipeline operation and the costs entailed thereby.

Slurry pipelines make use of centrifugal pumps located at a series of stations along the line. The mechanisms of such pumps are eroded by coal particles and affected by sub-zero weather, causing the water to freeze or become highly viscous. The pump, therefore, have a relatively short life, thereby adding to capital and maintenance costs. Because of the need for frequent maintenance, the pumping stations are located above ground to provide ready access thereto, whereas the line itself is usually buried underground. This arrangement creates a further complication; for with a centrifugal pump, the inlet thereto is in line with the pipe, whereas the pump has a peripheral exist which dictates a large bend to return the output of the pump to the inline direction at the pumping station.

As the piepline is lengthened from 600 miles to, say, 1000 miles and longer, and the capacity of the slurry system is enlarged, the cost per ton increases to a point where it approaches and possibly exceeds the cost-per-ton of a conventional unit-train system. Both conventional unit-train and slurry pipeline systems, when travel distances run about 1000 miles, involve transport costs estimated in 1981 money terms, to exceed $36 per ton. This cost is about three times the present cost of coal at the mining site.

The pressing need to switch from oil to coal as an energy source exists not only because of the ever-increasing cost of oil, but also by reason of the danger to the security of this country in having to rely on foreign resources under the control of unstable political regimes, Hence more is involved in a policy decision that cost factors. But in a free enterprise system, private energy users are primarily concerned with cost; and if the price of coal, because of high transport costs which are a multiple of the coal itself, renders the choice of coal less attractive, this will militate against switchover to coal irrespective of the fact that coal resources in the United States are enormous.

SUMMARY OF INVENTION

In view of the foregoing, the main object of this invention is to provide an efficient and reliable coal transport system which requires no water to operate and which makes it feasible to transport coal over long distances at a cost substantially lower per ton than existing unit-train or slurry pipeline systems.

More particularly, an object of this invention is to provide a tubular coal transport system in which coal is conveyed through a tube from a coal source to a receiving terminal over an extended distance, the coal being carried by a continuous succession of small, individually-powered cars travelling at low speed; for example, 15 miles per hour. While it takes any one slowly moving car travelling a distance of one thousand miles several days to traverse this distance, each car is quickly succeeded by another; hence it is as if the coal were being conveyed continuously through the tube.

Also an object of this invention is to provide a tubular system of the above type capable of delivering many millions of tons per year over an extended route without disturbing the communities in the path of the tube, for the tube readily lends itself to underground burial at crossing points.

Still another object of this invention is to provide a tubular coal transport system in which a succession of loaded coal cars travel through the tube in the forward direction and travel empty in a collapsed state in the return direction, the arrangement being such that the succession of loaded cars and the succession of empty tubes occupy substantially all of the available space of the tube, thereby making it possible to use a tube having a relatively small cross-sectional area.

Briefly stated these objects are attained in a tubular coal transport system in which a continuous succession of small, individually-powered loaded cars travel through a tube from a coal source to a receiving terminal over an extended distance. Each wheeled car has a generally cylindrical form and includes a bottom trough in which electric motors are installed to drive the car wheels at a controlled rate, and a cover composed of two arcuate sections hinged to the trough and foldable therein to collapse the car when it is empty, thereby reducing the volume of the car.

When loaded, the cars travel from the source to the receiving terminal along a forward track mounted on the base of the tube adjacent one side thereof. When empty, the collapsed cars travel back to the coal source on a return track mounted on the opposite side of the tube, the arrangement being such that the succession of loaded and empty cars travelling in opposing directions occupy substantially all available space in the tube.

OUTLINE OF DRAWINGS

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the following detailed description to be read in conjunction with the accompanying drawings, wherein:

Fig. 1 shows a first preferred embodiment of a tubular coal transport system in accordance with the invention, this view being a transverse section taken through the tube and through a loadec car going in the forward direction and an empty car going in the return direction;

Fig. 2 is a perspective view of the system, the tube being cut away to expose a loaded and an empty car;

Fig. 3 schematically illustrates the manner in which an empty car entering the transmitting terminal is loaded with coal before being admitted to the tube for travel to the receiving terminal;

Fig. 4 is a section taken in the plane indicated by line 4-4 in Fig. 3;

Fig. 5 schematically illustrates the manner in which a loaded car arriving at the receiving terminal is unloaded before being returned as an empty car to the tube;

Fig. 6 is a transverse section taken in the plane indicated by line 6-6 in Fig. 5;

Fig. 7 is a modified form of cylindrical car, shown in transverse section; and

Fig. 8 illustrates, in a transverse section taken through the tube, a second embodiment of the invention.

DESCRIPTION OF INVENTION

First Embodiment:

Referring now to Figs. 1 and 2, there is shown the tube 10 included in a tubular coal transport system in accordance with the invention. The tube, which in this embodiment has an elliptical cross-section, may be fabricated of many short sections, each of which is made of concrete or galvanized sheet steel or any other material appropriate to the environment in which the tube is located, suitable joints being provided to intercouple the sections. The length of the tube depends on the distance to be traversed between the coal source or transmitting terminal and the receiving terminal which may be a port or a transfer point.

Mounted on the floor of tube 10 adjacent the left side thereof is a forward track composed of parallel rails 11 and 12, the rails being constructed to take into account the curvature of the tube so that their wheel-engaging surfaces lie at the same level. Riding on rails 11 and 12 is a succession of individually-powered coal-carrying cars 13, each car having front and rear wheel sets 14F and 14R which run on the rails. Each wheel set is powered by its own motor (15F and 15R).

Car 13 has a generally cylindrical form and includes a lower trough 13A having a semi-cylindrical shape and an upper cover defined by a pair of arcuate sections 13B and 13C which are hinged to opposite sides of the trough. The hinge points H_1 and H_2 are at a level above the center plane P of the cylindrical car, so that when sections 13B and 13C are folded down, these sections then lie within trough 13A to collapse the car and thereby reduce its effective volume. In practice, the car includes catches to hold the cover sections in their folded-in positions. As shown in Fig. 2, each cylindrical car is enclosed by end plates 16 formed by semi-circular sections 16A and 16B, the upper section being hinged from the lower sections so that the upper section may be folded down when the car is empty.

Mounted for rotation on trough 13A on opposite sides thereof at a point just below center plane P are a pair of free-running guide wheels 17 which operate in bearings 17'.

When the cars are empty and in the collapsed state, as shown on the right side of Fig. 1, the cars travel on a return track mounted on the right side of the tube, the track being composed of parallel rails 18 and 19. In the return mode, center plane P is vertical and guide wheels 17 engage guide rails 20 disposed at the top and bottom of the tube. Motors 15F and 15R and the controls therefor are housed within an enclosure 21 at the bottom of trough 13A.

The cars travelling on the forward track are fully loaded with coal, the cars in this mode having their cover sections joined together to complete the cylinder in which in a practical embodiment may have a four foot diameter and a ten foot length. The collapsed cars travelling on the return track have a little more than half the volume of the loaded cars, hence occupy much less space in the tube. Since the loaded and unloaded cars run along their respective tracks in a continuous succession in close proximity to each other, the available space in the tube is almost fully exploited, thereby making it possible to provide a tube whose small cross-sectional area makes the per-foot construction cost of the tube relatively low.

Thus in Fig. 1, with a loaded cylindrical car having a four-foot diameter, which car is truncated in the empty state, the midplane width of the elliptical tube may be about 6-1/2 feet, and the center height about 4-1/2 feet.

Power is supplied to the forward and return tracks (11-12, 18-19) by a power grid, as in a conventional electrical railroad system, by way of a multiplicity of connections at suitable intervals along the 1000 mile route. Thus, in practice, a connection may be made at 10 mile intervals, this resulting in 100 connections. The wheels physically and electrically engage the power rails which act to supply power to the motors. Alternatively, the rails may be grounded and power supplied by an insulated power rail place between the travel rails and engaged by a shoe projecting below the car.

The contact surfaces of the rails are hardened to produce a low coefficient of rolling friction, thereby reducing energy requirements as well as extending the effective life of the rails. When the tube is fabricated of metal, the rails must, of course, be electrically insulated therefrom.

With the car dimensions given above, it is estimated that for normal operation of a coal-loaded car (i.e., 2 tons per car) at low speeds, such as 15 miles per hour, all that is required on level ground is 2 to 4 horsepower car. In order to provide reserve power for inclines, curves or speed-ups, or for abnormal conditions where, for the same reason, the motors in a given car are disabled and the car must be pushed by the succeeding car, the two motors 15F and 15R on each are 5 horsepower motors, so that the car has a 10 horsepower drive. This power is more than sufficient for special contingencies, as when the tube is buried below a crossing point and the car must therefore travel down and up a tubular underpass.

With cars having the above-noted dimensions and travelling at 15 miles per hour, it is estimated that the cost of delivering 100 million tons of Western coal per year over a 1000 mile route will run about 13 to 15 dollars per ton. This transportation cost is far below the per-ton cost with existing unit-train or slurry pipeline systems. By its very nature, a tubular coal transport system in accordance with the invention requires little maintenance within the tube, it needs no water at all, and affords a reliable, efficient and low cost system for transporting Western coal.

Ideally, all individually-powered cars in the tubular system should travel at precisely the same speed to maintain a fixed headway between succeeding cars. However, no two-car loads are exactly the same, nor do any two motors of seemingly like design turn at identical speeds, even with the same power input. Hence means must be provided to regulate the speed of the motors to maintain proper headway between the cars under normal and abnormal operating conditions.

Each car may, therefore, include a speed monitoring sensor operating in conjunction with a microprocessor which compares the actual or real time speed with a predetermined nominal speed and acts in response to any deviation therebetween to adjust the motor speed accordingly, thereby maintaining the desired car speed under varying conditions.

Or motor speed may be remotely controlled from a central computer through a carrier communication system which conveys digital information over the rails, each moving car having control signals addressed thereto by the same computer. To this end, the tube may be provided at spaced points along its length with transmitting stations whose field is intercepted by a detector borne by the car as the car passes therethrough. The signal then sent out by the car identifies the car and its speed relative to the transmitting station, this information being conveyed over the rails to the central computer which digests this information and then addresses to the car the corrective measures necessary to cause the car to move at the proper speed.

At the coal loading or input terminal for the tubular system as shown in Fig. 3, the collapsed empty cars from the return track of tube 10 are designated cars 13E and the loaded cars entering the forward track are designated cars 13L. The input terminal is provided with an input track section which intercouples the forward and reverse tracks and takes the form of a reversing loop RL_1. When an empty car 13E emerges from the return track in the tube, it travels through the reversing zone Z onto the lower course of the loop. The car then passes onto the upper course of the loop where, before it runs under a coal hopper 22, its hinged, folded-in cover sections 13B and 13C are folded out to render the car receptive to a load of coal, as shown in Fig. 4. The car cover sections are then closed and the end sections are raised before the car passes again through the reversing zone Z to enter the forward track in the tube.

At reversing zone Z the empty cars entering the input terminal and the loaded cars leaving the terminal are automatically inspected by inspection stations 23 or robots 24, a defective car being switched out of the reversing loop for maintenance before being returned thereto in proper working order.

At the unloading or output terminal, as shown in

Fig. 5, the track section intercoupling the forward and return tracks at the far end of the tube also take the form of a reversing loop RL_2 in which the loaded cars 13L, after passing reversing zone Z travel along the upper course of the loop. A conveyor belt 25 is located under the lower course of the reversing loop, the cover sections 13B and 13C of the cars being folded out (see Fig. 6), so that as the loaded cars pass into the lower course, the coal therein is dumped onto the conveyor. The cover sections of the empty cars are then folded in and the end plate sections are dropped before entering the return track in the collapsed state. Here again, robots 24 and inspection stations 23 serve to detect defective cars and to switch them out of the loop before going back into the tube.

Instead of providing cover sections for the cars which are hinged to trough 13A, use may be made of arcuate sections 13B' and 13C', as shown in Fig. 7, in the form of sliding doors. In this arrangement, the sections are either joined together at their adjacent ends to complete the cylinder, or they are angularly displaced to lie against the curved sides of the trough to open the car.

In some instances, particularly when land or right-of-way costs are low, use may be made, as shown in Fig. 8, of a tube whose cross-sectional dimension is large enough to accommodate two uncollapsed cars; one being loaded with coal, and the other being empty. These cars may be of the type previously disclosed, but there is no need to fold in the cover sections to reduce the volume of the empty car. One advantage of this arrangement is that the forward track formed by rails 11 and 12 and the return track formed by rails 18 and 19 may both be placed along the bottom of the tube, thereby obviating the need for guide rails, as in the Fig. 1 embodiment in which the empty cars travel on a return track mounted on a side wall. In other respects, the operation of the system in Fig. 8 is essentially the same as in Fig. 1.

While there has been shown and described a preferred embodiment of a tubular coal transport system in accordance with the invention, it will be appreciated that many changes and modifications may be made therein without, however, departing from the essential spirit thereof. For example, the same system may be used to carry bulk materials other than coal, such as grain.

CLAIMS:

1. A tubular coal transport system for conveying coal from a source to a receiving point over a long distance, said system comprising:

(a) A tube extending between the source and the receiving point, said tube having parallel forward and return tracks therein to which electric power is supplied;

(b) A plurality of individually-powered cars, each having a cylindrical form defined by a lower trough and an upper cover which is openable to admit or discharge coal to load or empty the car, each car having a front set of wheels and a rear set of wheels, and at least one motor energized by power derived from said tracks to drive one set of wheels;

(c) An input terminal at the end of the tube adjacent the source, said terminal being provided with an input track section intercoupling the forward and return tracks to conduct empty cars from said return track under a coal-loading station and to transfer the then loaded cars in successive order into the forward track; and

(d) An output terminal at the end of the tube adjacent the receiving point, said terminal being provided with an output track section intercoupling the forward and return tracks to conduct loaded cars from said forward track to a coal dumping station and to transfer the then empty cars in successive order into the return track whereby said tube is occupied by a succession of loaded cars and a parallel succession of empty cars.

2. A system as set forth in claim 1, wherein said tube is fabricated of corrugated sheet steel.

3. A system as set forth in claim 1, in which said tube is formed of concrete sections.

4. A system as set forth in claim 1, further including a second motor to drive the other set of wheels.

5. A system as set forth in claim 4, wherein each motor is a 5 horsepower motor.

6. A system as set forth in claim 1, in which the distance is about 1000 miles.

7. A system as set forth in claim 1, further

including means to control the motor to regulate the speed of each car to normally maintain a minimum headway between successive cars.

8. A system as set forth in claim 1, in which a power grid is provided to supply power to said tracks at spaced points along the tube.

9. A system as set forth in claim 1, wherein each car has a cover formed by two arcuate sections hinged to the trough, said sections, when the car is empty, being foldable into the trough to reduce the volume of the car and thereby collapse the car.

10. A system as set forth in claim 9, wherein said return track is mounted on a side wall of the tube, the forward track being mounted on the floor of the tube adjacent the other side.

11. A system as set forth in claim 10, wherein said tube has an elliptical cross-section whose area is such as to accommodate the succession of loaded cars and the parallel succession of collapsed cars which together almost fully occupy the tube.

12. A system as set forth in claim 11, wherein said trough is provided at opposite sides with guide wheels which engage guide rails mounted on the top and bottom of said tube to retain the empty cars on the return track.

13. A system as set forth in claim 1, wherein said cover is formed by two arcuate sections which are slidable along opposing sides of the trough to open or close the car.

14. A system as set forth in claim 1, wherein said cars have a diameter of about four feet.

15. A system as set forth in claim 14, wherein said cars travel at a speed of about 15 miles per hour.

16. A system as set forth in claim 1, wherein the track sections of the terminals have a reversing loop.

17. A system as set forth in claim 16, further including an inspection station to remove a defective car from the loop.

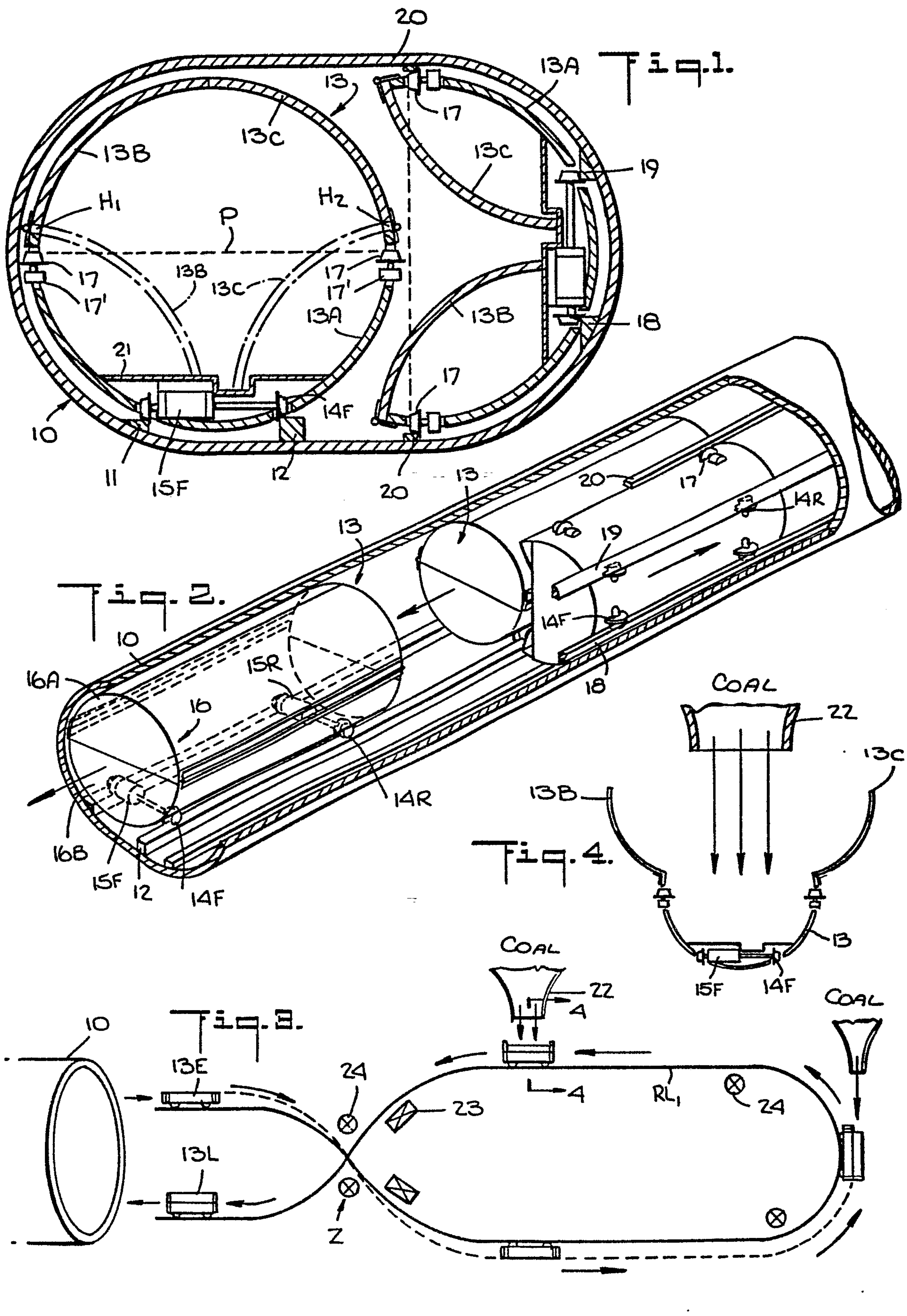

Fig.1.

Fig.2.

Fig.3.

Fig.4.

Fig. 5.

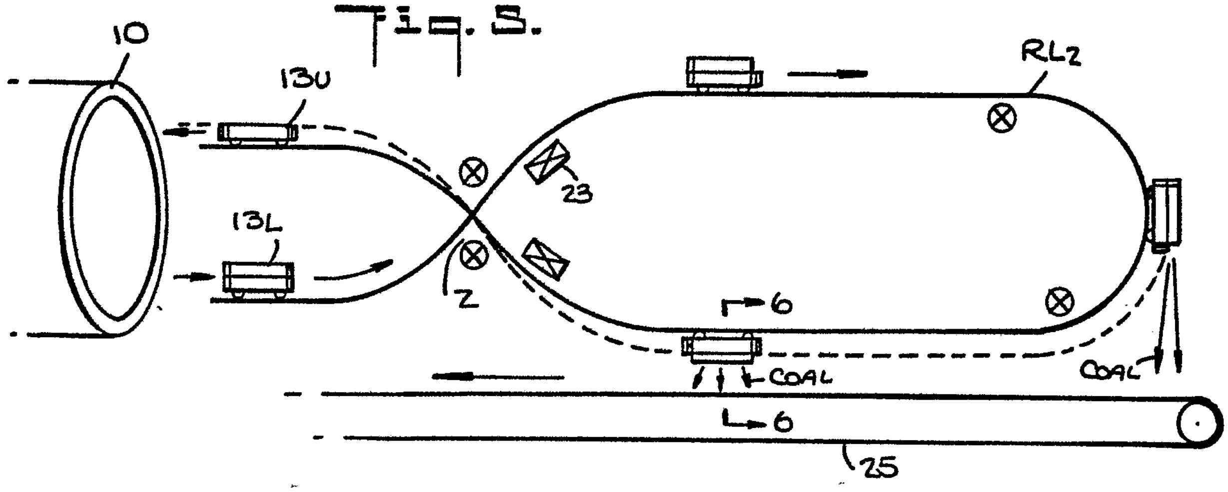

Fig. 6.

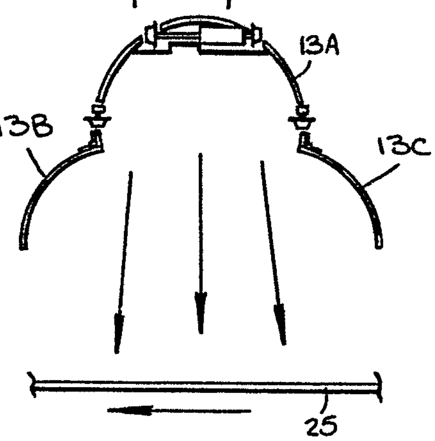

Fig. 7.

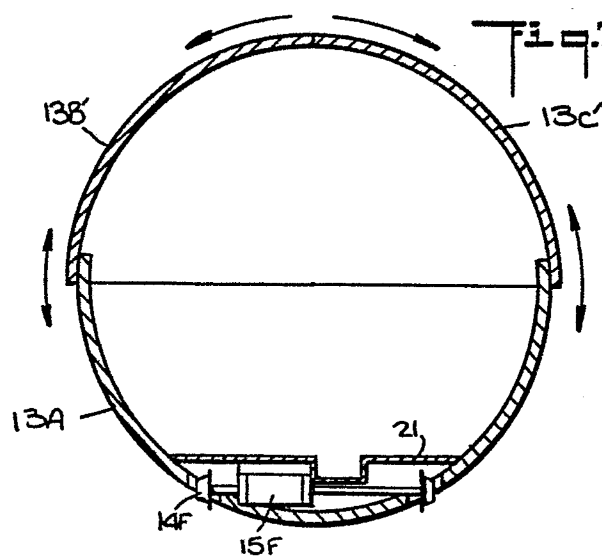

Fig. 8.