

Jan. 9, 1962

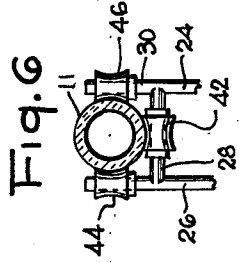
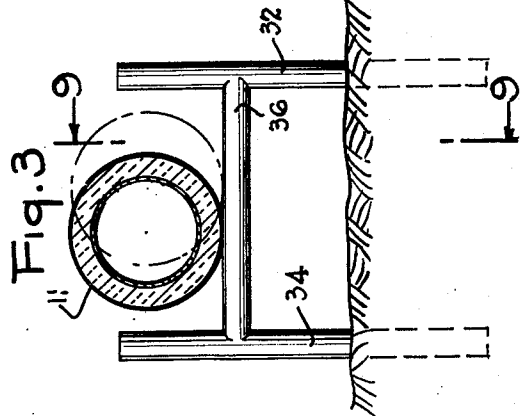
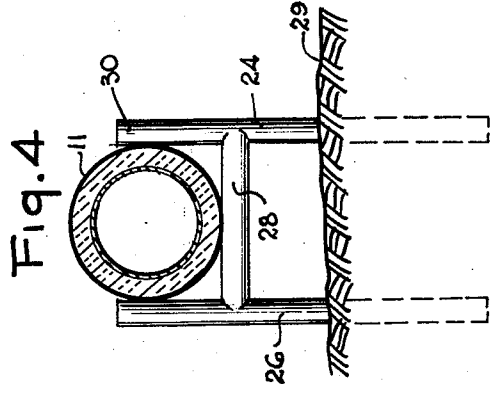
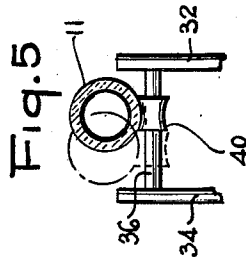
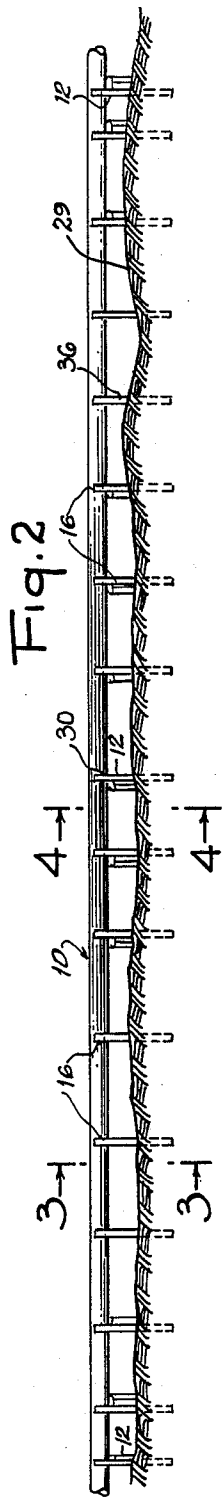
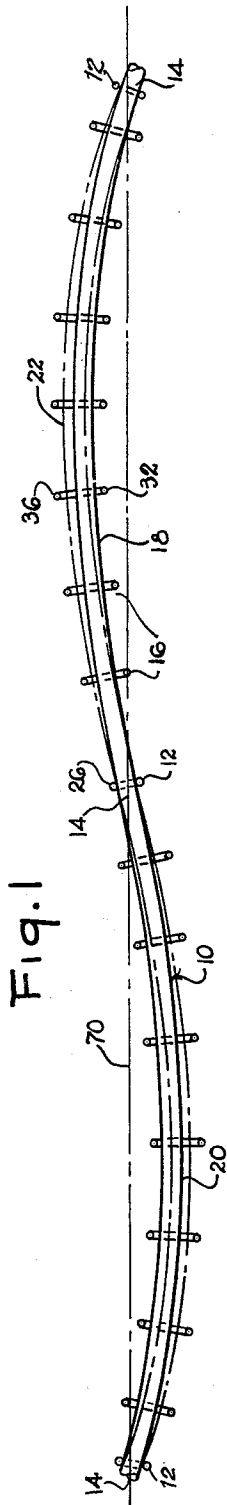
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3,016,219

TRANSMISSION LINE FOR COLD LIQUIDS

Filed June 30, 1958

2 Sheets-Sheet 1



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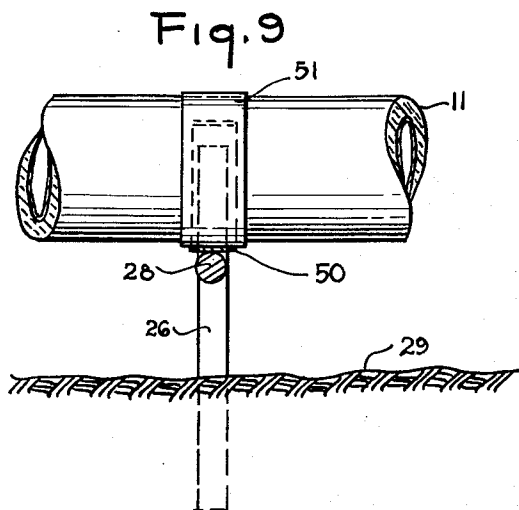
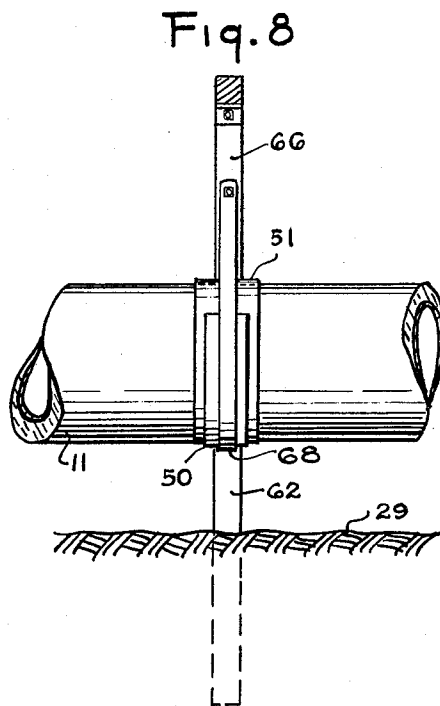
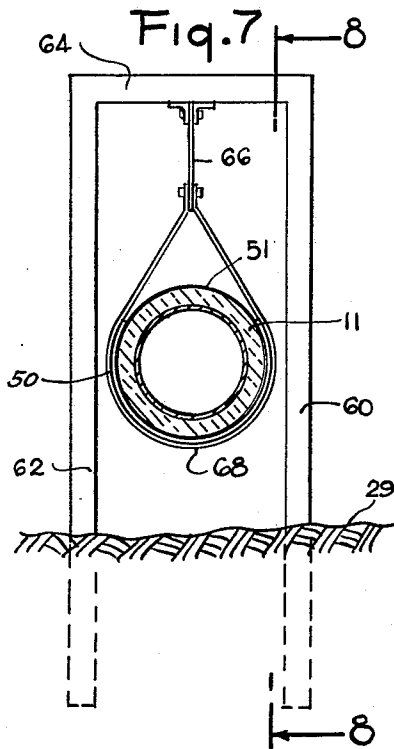
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TRANSMISSION LINE FOR COLD LIQUIDS

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2 Sheets-Sheet 2



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TRANSMISSION LINE FOR COLD LIQUIDS

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5 Claims. (Cl. 248—55)

This invention relates to a pipe line for use in the transmission of a liquid having a temperature which differs widely from ambient temperature and it relates more particularly to a pipe line for use periodically to transmit an extremely cold liquid over a substantial distance.

The invention is addressed to the solution of a particular problem in the transmission of natural gas while in a liquefied state at about atmospheric pressure but the concepts described and claimed will be applicable also to the transmission of other extremely cold liquids or fluids. Thus the invention will be described with reference to liquefied natural gas which, at atmospheric pressure, has a critical boiling point below -240°F ., depending somewhat upon the amount of heavier hydrocarbons present in combination with the methane in the natural gas.

The problem arises where there is a need to transmit the liquefied natural gas from one point to another, either at the source of supply or at the source of use. It is known that natural gas is in excess supply in certain localities while deficiencies of natural gas or other low cost fuels exist in other localities. Where the area of supply is connected to the area of use by land, transmission can easily and economically be effected by pipe line transmission while in a gaseous state. Where, however, the source of supply and the area of use are separated by a large body of water or by a substantial distance, transmission by pipe line becomes impractical.

It is possible to house the natural gas in containers for shipment but the heat value available in the amount of gas that can be confined in suitable containers is insufficient to justify the cost of such transmission. Natural gas is capable of being reduced in a ratio of 600 to 1 when converted to the liquefied state, at equivalent pressure, so that it becomes economical and practical to liquefy the gas at the source of plentiful supply for transportation in a liquefied state to the area where a deficiency exists where the liquid can be reformed into a gas for use. Processes for liquefaction and reforming the liquefied gas are available and means have been developed for housing the liquefied gas in insulated tanks for storage and for transportation by water from the area of excess supply to the area where the deficiency exists.

In the transportation of the liquefied gas, it is impractical and undesirable to tie up the transportation means at the source of supply for a length of time sufficient to fill the insulated tanks with the gas as it is being liquefied. It is equally undesirable to tie up the transportation means at the area where the deficiency exists while the liquid in the tank is being converted to the gaseous state for use. It is more desirable from the standpoint of efficiency and economy in operation to make use of a continuous liquefaction cycle and store up the gas as it is being liquefied in liquid storage tanks to build up a supply sufficient to fill the ship's tanks and to make use of land storage tanks at the area where the deficiency exists into which the liquid can be discharged from the ship's tanks thereby to free the ship and provide a reservoir of liquid which can be fed as demanded to the reforming process.

Such land storage tanks are best located adjacent the liquefaction site or the reforming site. For various reasons, these sites may be located some distance inland or away from the transportation means. As a result,

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it becomes necessary to provide means for the rapid transmission of the cold liquid from the land storage tanks to the tanks of the transportation means or vice versa.

A number of problems arise in the transmission of an extremely cold liquefied gas of the type described. The problems become further aggravated by the fact that liquid transmission is not constant but may occur periodically with a considerable space of time in between.

Ignoring the type of material of which the piping is formed for use in transmission, it will be apparent that such piping will rise to ambient temperature during the extended period of non-use. When used for the transmission of the liquefied gas in large volume at a temperature of about -250°F ., a considerable amount of contraction will take place as the materials of which the piping is formed are reduced in temperature from ambient temperature to about the temperature of the liquid, at least in the portions adjacent the surfaces in contact with the liquid. Such contraction will result in certain relative movements that will tend to assert a lengthwise contractual force and hoop forces in the piping. When the flow of liquid ceases, materials of the pipe will gradually heat up again to ambient temperature with resultant expansion to convert the contractual forces to expansion forces which can be easily destructive.

It is an object of this invention to produce and to provide a method for producing a line for the transmission of a liquid having a temperature differing widely from the ambient temperature and it is a related object to produce a transmission line which is free to shift in response to the existence of contractual or expansion forces without destruction or deterioration of the transmission line and without interfering with the operation thereof.

More specifically, it is an object of this invention to produce a line for the transmission of a cold boiling liquefied gas, such as natural gas, at about atmospheric pressure and at a temperature less than about -240°F ., which is used only for short periods of time for transmission of the liquefied gas; which is free to contract when cooled down by the liquid being transmitted there-through; which is free to expand when heated up by the ambient atmosphere; which is supported substantially throughout spaced portions of its length in positions above ground; which is easy to construct and operate, and which is formed of relatively few parts which are quickly assembled into a continuous transmission line for communicating the source of supply with a receiver.

These and other objects and advantages of this invention will hereinafter appear and for purposes of illustration, but not of limitation, embodiments of the invention are shown in the accompanying drawings in which—

FIGURE 1 is a top plan view of a substantial length of the transmission line embodying the features of this invention;

FIGURE 2 is an elevational view of the portion of the transmission line shown in FIGURE 1;

FIGURE 3 is a sectional view taken along the line 3—3 of FIGURE 2;

FIGURE 4 is a sectional view taken along the line 4—4 of FIGURE 2;

FIGURE 5 is a sectional view similar to that of FIGURE 3 showing a modification in the construction;

FIGURE 6 is a sectional view similar to that of FIGURE 4 showing a modification in the construction;

FIGURE 7 is a sectional view through a section of the pipe showing a modification in the mounting means;

FIGURE 8 is a sectional view taken along the line 8—8 of FIGURE 7, and

FIGURE 9 is a sectional view taken along the line 9—9 of FIGURE 3.

The invention is addressed to the construction of the transmission line as distinguished from the materials of which it is formed. As a result, little consideration will be given to the structural materials other than to state that the lengths of pipe 11 which are interconnected in end-to-end relation to form a continuous pipe line 10 can be formed of metal, insulated metal, insulated wooden sections with or without a metal inner face, or of honeycomb sections having a continuous inner face which is adapted to be contacted by the liquid.

The manner of assembly is also unimportant to the concepts of this invention. Suffice it to say that the length of pipe may be joined together in end-to-end relation by welding, by splines, by sealed telescoping sections or the like. What is important is the means for mounting and supporting the interconnected sections of pipe to permit the described expansions and contractions to be repeated again and again in use without deterioration or destruction of the pipe and it is toward this concept that this invention is addressed.

The usual practice is to lay the transmission line under ground. While this is suitable for natural gas, petroleum products and the like fluids which are capable of transmission at or about ground temperature, it is not so practical with a liquid which is at extremely low temperature. The ground serves as a protective covering to the extent that the cold is capable of transmission slowly through the insulation to the adjacent ground whereby the ground is caused to freeze with resultant upheavals which provide instability to the supporting surface and which may cause the release of such forces as would prove destructive to the transmission line. Thus a pipe line for the transmission of liquefied natural gas or the like cold liquid is adapted to be constructed above ground and in spaced relationship therewith for enabling substantially full circulation of air about the sections of pipe with the exception of the periodic supports.

In accordance with the practice of this invention the above ground transmission line is constructed to make a serpentine path in a horizontal plane through the length thereof with pivotal supports 12 at the cross-over points 14 and horizontal rests 16 spaced periodically in between on which the lengths of pipes are supported. Such arrangement permits crosswise shifting movement relative to such rests in response to the expansions and contractions taking place throughout the lengths of the pipe.

The serpentine arrangement in which the pipe line is constructed provides oppositely bowed sections 18 and 20 of substantial length to precondition the lengths of pipe in a manner to enable the magnitude of the bow to increase in response to expansion, as indicated by the broken line 22, or to decrease in response to contraction, as indicated by the position in solid lines in FIGURE 1. Without preforming the lengths into bowed sections, the expansion and contraction forces would introduce linear stresses which could build up in the pipe to a point of possible rupture or separation. With the lengths of pipe arranged in opposite bowed portions, expansion and contraction movements will be controlled by such prearrangement. It is desirable to stabilize the positions of the transmission line at its cross-over points 14. For this purpose, use is made of a support which maintains the pipe at the cross-over point at the desired level off of the ground while permitting the pipe sections to pivot or rock in the horizontal plane about a pivot at or about the cross-over point and which preferably but need not permit a small amount of relative endwise displacement of the pipe sections relative to the support.

The described pivotal support at the cross-over points can be provided in a number of ways. As illustrated in FIGURE 4, the pivotal support at the cross-over point may comprise uprights 24 and 26 anchored into the ground 29 and spaced apart by a distance corresponding to the outside dimension of the length of pipe so as to receive the pipe in substantially fitting relationship there-

between. The support is provided with a cross-bar 28 which extends crosswise between the uprights in spaced relationship from their upper ends but above the ground to provide a shelf upon which the pipe rests whereby the section of pipe is held in the support in a manner to minimize crosswise displacement but to permit pivotal movement about a vertical axis and also to permit a limited amount of lengthwise displacement relative to its support. The confining members may be formed of wood or metallic material. The surfaces in position to be engaged by the piping may be formed flat for maximizing the support but it is preferred to form the upright posts with curvilinear surfaces in position to be engaged by the pipe to enhance the pivotal action.

It will be understood that the uprights 30 extending upwardly beyond the shelf 28 to engage the pipe therebetween may be otherwise constructed as abutments extending upwardly from a shelf having a cement base. The uprights may also be formed to a curvilinear contour more substantially to embrace the length of pipe received therebetween.

The distance between the pivotally mounted cross-over points may represent a substantial length such as many hundreds of feet or a mile or a fraction thereof. It is desirable to support the lengths of pipe between the cross-over points but without interfering with the free movement of the pipe laterally to increase or decrease the arc of the bow in response to expansions or contractions taking place in the lengths of pipe. For this purpose, the uprights 32 and 34 are anchored into the ground in spaced apart relation substantially greater than the crosswise dimension of the length of pipe received thereon. A cross bar or brace member 36 is fixed at its opposite ends to the uprights 32 and 34 in spaced relation from the upper end thereof but above the ground whereby the pipe is retained within the support in a manner to permit a limited amount of crosswise displacement while militating against displacement of the pipe from its support. For all practical purposes, the platform or supporting cross member 36 may be dimensioned to have an effective width between the uprights which is only a few feet greater than the cross-section of the length of pipe closely adjacent the cross-over points 14 but with an increased spaced relation to perhaps 3 or 4 feet midway of the cross-over points where relative movements are maximized. Various types of bracing may be employed for anchoring the uprights and the support with the supporting shelf 36 at the level desired for use.

By way of modification, the crosswise support 36 may be provided with a spool 40 mounted thereon for free turning movement. The spool is formed with a surface contour dimensioned to correspond with the contour of the section of pipe received thereon so as to provide a more substantial rest for the pipe and to guide the pipe in its relative crosswise movement with reference to the support. In the illustrated modification of FIGURE 5, where the lengths of pipe are cylindrical in shape, the periphery of the spool is formed concave with a curvature corresponding to the curvature at the outside of the pipe.

The same concepts may be employed with respect to the pivotal support at the cross-over point wherein a spool 42 is mounted for free rotational movement in a fixed position on the cross bar 28 and other spools 44 and 46 are mounted for free rotational movement on the uprights 30, in a fixed position on the uprights to engage the lateral surfaces of the length of pipe disposed therebetween. Thus more substantial and effective support is provided for the pipe while permitting pivotal movement in the crosswise direction and linear movement in the lengthwise direction. When the pipe is of a cylindrical shape, each of the spools may be formed with a concave peripheral surface having a curvature corresponding with the curvature at the outside of the pipe.

In the light of the fact that the pipes will be of substantial dimension and of considerable weight, it is desirable

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to provide the supporting sections of the pipe with saddles 50 in the form of metal or hardwood sections on which the pipe rests without causing wear or deformation of the sections of pipe. It is desirable also to protect the engaged portions of the pipe with a band 51 which may completely encase the section of pipe or it may constitute a section which merely extends about the portions of the pipe in position to be engaged by the various abutments and supports, or both the saddle and band may be used.

A modification in the means for supporting the lengths of pipe above ground in a manner to permit sidewise movements between the cross-over points and which is limited to pivotal movements at the cross-over points with a small amount of endwise displacement is shown in FIGURES 7 and 8 wherein upright members 60 and 62 are anchored into the ground for support and interconnected at their upper ends with a cross rail 64. Depending from an intermediate portion of the cross rail and secured thereto is a sling 66 having a hoop portion 68 at the lower end dimensioned to receive an increment of the pipe therein. The sling support may be employed at the cross-over points when the uprights 60 and 62 are laterally spaced apart by a distance substantially corresponding to the outside dimension of the pipe received therebetween to minimize crosswise displacement while enabling free pivotal movement in the horizontal plane. The sling section will also permit a limited amount of lengthwise movement while still tending to center the cross-over point between the support.

The sling arrangement can also be employed to provide the support between the cross-over points by spacing of the uprights by an amount greater than the crosswise dimension of the piping to enable lateral displacement of the pipe in the amount calculated to take place. In the sling arrangement as in the support arrangement, it is desirable to provide a saddle about the portions of the pipe engaged so as to enhance the operation and protect the pipe sections. It will be understood that the supporting means described may be used in the various combinations.

In practice, the differences between the distance between the cross-over points, as indicated by the neutral line 70, and the length of the bowed section of pipe between such points should be greater than the amount of contraction taking place in the length of the piping between the crossover points in response to a temperature change of about 350° F. In the illustrated modifications, the serpentine configuration is somewhat exaggerated. Actually, the arch in the bowed length of pipe will be less significant than shown.

It will be understood that the transmission line may be formed of joined lengths of pipe which are square, round, or of other polygonal shape in cross-section. The pipe is preferably formed of an internal diameter sufficiently large to enable free flow of the liquid, with and preferably without pressure. The latter is preferred with wooden pipe of large cross-sectional dimension and, for this purpose, it is desirable to rely upon gravitational flow of the liquid through the pipes from a supply source at higher level than the receiving end.

It will be apparent from the foregoing that the transmission line will comprise a substantially free body throughout its length since the sections of the piping will be capable of flexing action to compensate for changes in length or dimension and the line will be capable of a limited amount of endwise displacement relative to the supports to enable one section to accept thrusts or forces transmitted from others in endwise alignment therewith. While the transmission line is capable of acting as a free body, it nevertheless is guided in its movements and is controlled in its operation to provide adequate support throughout its length and to predetermine the positions of the inlet and outlet at the opposite ends.

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It will be understood that use may be made of various materials in the construction and in the operation of the elements and that other changes may be made in the details of construction and arrangement without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. In a line for the transmission of an extremely cold liquid comprising the combination of lengths of pipes arranged in end-to-end relation to form a continuous line preformed to a serpentine configuration in the horizontal plane, means supporting the line at the cross-over points of the serpentine arrangement for pivotal movement thereabout in a horizontal plane with essentially no displacement in the crosswise direction while permitting longitudinal movement thereof relative to the support, and a plurality of means supporting the line at a plurality of spaced apart points intermediate the cross-over points for relative displacement of the supported sections of the line in the crosswise direction as well as in the longitudinal direction, wherein the means for supporting the line at the crossover points comprises a horizontally disposed supporting shelf and uprights extending upwardly from the shelf in spaced apart relation crosswise on the shelf corresponding to the crosswise dimension of the outside of the portion of the pipe received therebetween and the means for supporting the line at the spaced apart points intermediate to the crossover points comprises a horizontally disposed supporting shelf and uprights extending upwardly from the shelf in laterally spaced apart relation dimensioned to be substantially greater than the crosswise dimension of the outside of the pipe sections received therebetween whereby the pipe sections are capable of relative displacement crosswise on the support.

2. A transmission line as claimed in claim 1 which includes rollers on the supporting shelves at the crossover points mounted for free rotational movement in fixed position on the shelves.

3. A transmission line as claimed in claim 2 which includes additional rollers on the uprights having the outer surfaces contoured to correspond to the contour of the corresponding lateral sections of the pipe and mounted for free rotational movement in fixed position on the uprights.

4. A transmission line as claimed in claim 1 which includes a roller mounted for free rotational movement and for free crosswise displacement on the supporting shelves at the points intermediate to the crossover points and having a contour corresponding to the outside contour of the pipe adapted to rest thereon.

5. A transmission line as claimed in claim 1 which includes rollers mounted for free rotational movement in fixed position on the uprights in crosswise alignment with the central portions of the pipe adapted to be received therebetween and having a contour in the outer surface corresponding with the contour of the pipe and spaced one from the other by a distance greater than the crosswise dimension of the pipe at the points intermediate the cross-over points.

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