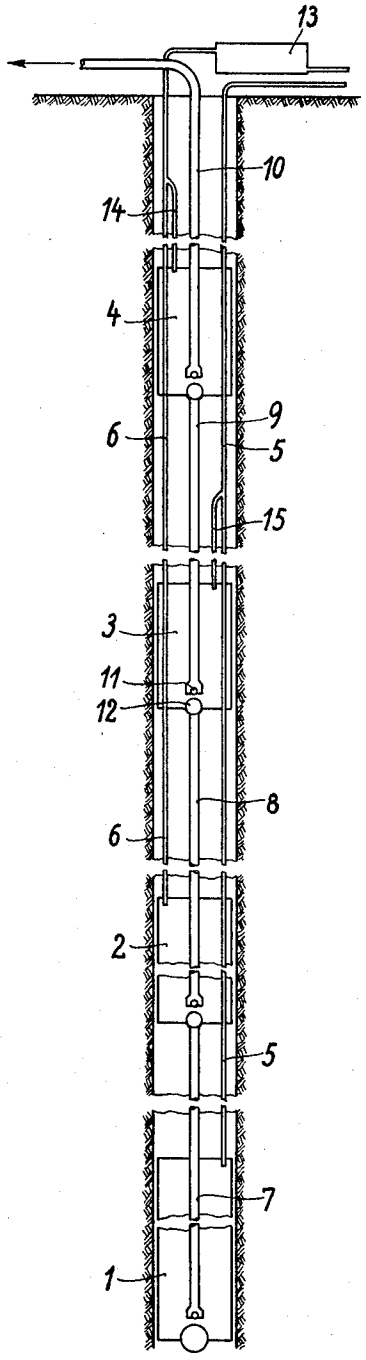
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PNEUMATIC DELIVERY PLANT FOR RAISING LIQUIDS FROM GREAT DEPTHS

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PNEUMATIC DELIVERY PLANT FOR RAISING LIQUIDS FROM GREAT DEPTHS

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1 Claim. (Cl. 103—239)

Liquid pressure installations with bells arranged in stages and provided with automatically controlled shut-off members are known, in which the delivery of the liquid is effected by periodical changes of pressure. These installations fail when it is a question of delivering liquids of varying viscosity, particularly viscous liquids, such as petroleum, water containing gas, lyes and the like, from very great depths, since in delivering from very great depths differences of temperature occur in the individual bells, as a result of which, in delivering from one stage to the next, owing to the different frictional losses that occur in the delivery pipe, manometric delivery heads of different magnitudes occur.

In the case of the great depths that come into consideration more particularly in delivering petroleum, amounting to 800 metres or more, the liquid to be raised has a considerably higher temperature at the bottom than it has when discharged at the ground level, and the viscosity of the oil to be delivered is also influenced by its greater or smaller percentage of gas, which may also be influenced by its transfer to the successive delivery bells. Even at a depth of 100 metres it is already necessary to take into consideration that the temperature of the oil to be delivered is about 40° C. at the point where it is taken in, whereas at the point of delivery above ground it has fallen to between 20 and 30° C. Furthermore the viscosity of the oil is also appreciably influenced by the removal of gas therefrom when the oil is being pumped from one delivery bell into the one above it.

Owing to these losses of heat and gas the viscosity of the crude oil increases, so that very different pressures are necessary for delivering it into the successive delivery bells. Owing to this the bells are not all filled in the same length of time, but the lower bells, in consequence of the smaller frictional losses in the pressure pipe, are filled considerably more quickly than the upper bells. As a result of this, the continuous delivery of the plant is endangered, unless the differing viscosity of the oil occasioned by the change of temperature and by the withdrawal of gas from the oil is allowed for.

These fluctuations in viscosity, and the differences of pressure occasioned thereby, do not admit of being satisfactorily dealt with by calculation, since the viscosity of the oil is also affected by subsidiary phenomena, which cannot be supervised, for instance at the commencement of the delivery the conditions are quite different from what they are when the plant has been in operation for a long time, as the temperatures gradually tend to become equalized. Furthermore it has already been mentioned that the alteration in the viscosity is also dependent upon the losses of gas. It is not possible to design the individual delivery bells at definite distances apart determined on the basis of these phenomena, for other delivery conditions also arise, as already explained.

The regulating of the fluctuations of viscosity that occur by the insertion of valves, controlling members, or floats in the bells arranged at great depths is practically impossible, particularly when it is borne in mind that in the petroleum there are serious impurities, particularly sand, which precludes the reliable working of such sensitive members, specially as the well bores driven to great depths are only of very small diameter, and thus the controlling members could only be given small dimensions. Such solutions would be impracticable since the use of the controlling members in installations of very great depths is very costly, requires time, and interrupts the continuous operation, which is desirable for the delivery of mineral oil. Since for all the parts located below ground the highest requirements as regards reliability and durability have to be made, the problem of providing for satisfactory and reliable working of the superposed bells, and of allowing for the arbitrary differences of viscosity of the oil to be delivered and of the different delivery pressure heads that adjust themselves, must be solved in some fundamentally different manner.

According to this invention the lowest bell is made considerably larger than those above it, and all the delivery bells, with the exception of the two lowest, are connected with their delivery pressure pipes by an elevated connecting pipe in each instance, acting as a pressure-compensating pipe.

The output of the plant as a whole is determined by the quantity of oil entering the lowest bell in a length of time fixed by positively acting controlling means. Owing to the varying percentage of gas in the oil, and owing to the varying position of the underground oil surface level outside the well, it is not possible always to admit the same quantity of oil into the bell in the predetermined constant unit of time. For this reason the volume of the lowest bell is increased to act as an accumulator or storage space. From this bell the same quantity of oil is then always delivered. Since in a unit of time unequal quantities flow in, it follows that by the enlarging

of the bell the same quantity of oil can constantly be taken out of the bell.

One example of construction of the delivery plant according to the invention is illustrated in longitudinal section in the accompanying drawing.

The lowest bell 1 fitted into the bore pipe is of considerably greater capacity than the bells 2, 3 or 4. The bell 2 is made somewhat larger than the bells 3 and 4, which are equal to one another in size. The delivery bells 1 and 3 are connected to an air pipe 5, which passes through the bells 2 and 4 without communicating with them. The bells 2 and 4 are connected to an air pipe 6, which traverses the bell 3. The delivery bells are connected with one another by delivery pipes 7, 8, 9 and 10, which are closed by ball valves 11, 12 or the like. In order to compensate for the oscilating masses of air, there is arranged in the pipe 6, which is the shorter one of the two air pipes, a compensating reservoir 13, the volume of which corresponds to the difference in volume between the two pipes 5 and 6. The bells 3 and 4 are connected to pipes 14 and 15 extending upwards therefrom and communicating with the air pipes 5 and 6 respectively at points a considerable distance above the bells with which they are connected, as indicated in the drawing, where the pipe 14 reaches nearly up to the surface of the ground and the pipe 15 reaches nearly up to the bottom of the bell 4. The length of the pipes 14 and 15 is determined by the spacing of the bells.

The method of operation of the plant is as follows:—

After the bell 1 has become full the pipe 5 of the bells 1 and 3 is supplied with compressed air. The bell 1, in consequence of the smaller viscosity of the oil, will begin to empty itself sooner than the bell 3, in which, in consequence of the higher viscosity of the oil, a higher pressure is required than in the bell 1, and the oil will flow to the bell 2, and, because the volume of the bell 1 is greater than that of the bell 2, will also fill part of the air pipe 6. With this filling of the air pipe 6 of the bell 2, however, the pressure also rises in the air pipe 5 of the bells 1 and 3, and it continues to rise, until the pressure required for delivering the liquid from the bell 3 to the bell 4 is reached, after which the emptying of the bell 3 into the bell 4 commences.

When the compressed air, after the reversal, acts through the air pipe 6 upon the bells 2 and 4, the oil in the air pipe 6 will be forced back into the bell 2, and part of the oil in the bell 2 will ascend, after filling the bell 3, into the connecting air pipe 15 of the bell 3, because the volume of oil that had been contained in the bell 2, together with the volume of oil that had previously been forced up into the pipe 6, cannot be accommodated by the bell 3 alone. Owing to the ascent of the oil into the pipe 15 a rise of pressure takes place in the pipe 6, and also acts through the elevated connecting air pipe 14 upon the bell 4, so that in the latter the pressure rises, and it can empty itself above the surface of the ground.

It will be understood that if the pipes 5 and 6 were directly connected to the tops of the bells 3 and 4 in the usual manner, without the interposition of the pressure-compensating pipes 15 and 14 respectively, then when the surface level of the oil in the bell 3 for instance reached the point of connection between this bell and the pipe 5, any continuance of the air pressure applied to the bell 2 through the pipe 6 would simply cause the oil to leak out of the bell 3 and flow down the supply pipe 5 into the bell 1, thereby wasting the work already done in raising it, besides preventing any rise of pressure in the pipe 6.

The elevated connecting pipes 15 and 14, which serves as compensating pipes for the different delivery pressures that prevail between the individual bells, will accordingly compensate quite automatically for those irregular changes of viscosity which might produce disturbances in the pumping operation.

The compressed delivery air becomes enriched with mineral oil gases in the course of operation. This enrichment may continue to such an extent as to produce an explosive mixture of air and gas, containing from 6 to 7 per cent. of mineral oil gas. In order to obviate this risk, instead of operating the apparatus with air, it is operated with a mixture of air and gas containing from 50 to 60 per cent. of mineral oil gas, which is obtained directly from the bore hole.

What I claim is:—

Delivery plant operated by compressed air or gases for raising liquids, particularly mineral oil, from great depths, comprising a series of superposed delivery bells, the lowest delivery bell being considerably larger than any of the others, liquid delivery pipes connecting the successive bells with one another, a pipe for supplying gaseous fluid under pressure to the lowest delivery bell and to the alternate delivery bells above it, a shorter pipe for supplying gaseous fluid under pressure to the lowest delivery bell but one and to the alternate delivery bells above it, a compensating reservoir communicating with the shorter supply pipe, the volume of the compensating reservoir corresponding to the difference in volume between the two supply pipes, elevated pressure-compensating pipes connecting all the bells except the two lowest individually to the supply pipes, and means for producing periodical changes of pressure in the delivery bells through the medium of the supply pipes.

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