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METHOD FOR LOADING AND EXPLODING CHARGES IN A BOREHOLE

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4 Claims. (Cl. 102—23)

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This invention is concerned with the loading and exploding of explosive charges in bore-holes and has particular application to seismographic prospecting and other operations in which a series of explosive charges are exploded in a single bore-hole.

In seismographic prospecting, a bore-hole is drilled in the earth, an explosive charge is loaded thereinto and exploded, and the resulting seismic waves are picked up at the surface of the earth and measured with one or more seismographs. When a series of charges are to be exploded in the same hole, it is frequently desirable to load more than one charge into the hole at or about the same time and so spaced from each other in the hole that the explosion of one does not set off the other. This procedure is economical of time and energy, but frequently is impracticable when the charges have to be exploded at or near the same depth in the hole. In such case, the charges cannot be placed close to each other initially without danger of one setting off another. Moreover, in many cases an upper charge cannot be lowered toward the position of a lower charge after the explosion of the latter by reason of the fact that the explosion frequently caves and clogs or bridges the hole between the two charges. And even when the charges are to be exploded at points sufficiently spaced from each other that the explosion of the lower charge cannot set off an upper charge, the upper charge may be blown up or completely out of the hole. If the charge is merely blown up the hole, the original and desired spaced relationship of the two charges is altered, and if the charge is blown completely out of the hole there is danger of explosion at the surface with consequent hazard to persons and property.

As a result of my investigations, I have discovered that when the bore-hole is filled with a fluid, for example air (but preferably a liquid such as water or drilling mud) to a level above the upper of two vertically spaced charges and the upper of the two is relatively free to move down the hole, the explosion of the lower charge tends to create a strong suction in the hole below the upper charge which is sufficient to draw the upper charge down the bore-hole, even to the point at which the lower charge was exploded. I have discovered, moreover, that if the upper charge is permitted to drop in the hole substantially immediately after the lower charge is exploded (i. e. within the few seconds or so thereafter) and while the suction created by the explosion is still high, the caving of the hole seldom

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interferes with the lowering of the upper charge, possibly because the elapsed time is insufficient to permit the hole to become clogged with sufficiently consolidated fragments from the wall of the bore-hole. Whatever be the explanation, the fact remains that under the conditions described, the upper charge can be lowered to almost any desired position in the hole in the first few seconds after the lower charge is exploded, with consequent saving in time and trouble involved in cleaning out a bore-hole between shots when a number of charges must be exploded at or about the same depth in the hole.

Preferably the upper charge is held in its initial vertical position by a line or lines (for example, a shot-fire cable or cables) fastened to the charge and extending up the bore-hole to the surface. Immediately after the lower charge is fired, usually by an electrically actuated detonator or blasting cap, the line is payed out and the upper charge is permitted to be sucked or dragged into the hole to the desired level, further progress down the hole being prevented by tightening the line and finally snubbing it in the correct position.

If desired, a series of several upper charges may be introduced at the same time, and lowered into the hole one after the other as preceding charges are exploded.

It is desirable to employ a plug in the hole above the uppermost charge to prevent a blow-out of an unexploded upper charge, since such a charge, especially if it contains a detonator, would create a hazard if it was blown out of the hole and exploded in the open air. Preferably the plug should have in it a vent of such dimensions or configuration that it prevents the charge from passing upward, and should also be so constructed that the shot-fire cables connected to the charges pass through it freely when the charges are lowered after each shot. The plug should be placed in the hole after the charges are initially set and may be of several forms, as described in detail hereinafter.

I have found that it is desirable to attach to the upper charge an expansible member which presses against the side of the hole and keeps it from being blown up the hole when the explosion occurs below it. At the same time the expansible member should be so constructed that it does not impede the movement of the shot down the hole. This may be accomplished by providing means for releasing the pressure of the member against the side of the hole when the charge is to be lowered, but a preferred form

it may be moved both up and down in the hole during the loading operation. For example, if during loading, a charge should be placed too deeply, it may be pulled back up the hole to the proper level by exerting tension on the shot-fire cable.

Despite the fact that with the device of Fig. 3, the charge is not anchored to the side wall and may be moved up the bore-hole during the loading operation with relative ease, the springing action of the attachment is sufficient to hold the charge at the correct level during the explosion of that charge or a lower one. The reason for this is not entirely apparent, but the fact remains that in many, if not most instances, the device of Fig. 3 is at least as efficient as that of Fig. 2 in preventing a charge from being blown out by the explosion of a lower charge. This is particularly true in hard formations, where the barb of the attachment of Fig. 2 does not penetrate the wall of the bore-hole to any substantial degree and hence may offer less bearing surface than is obtained with the side of the leaf spring in the device of Fig. 3.

Referring now to Fig. 4, it will be seen that it provides a means for forming a plug of concrete or other plastic settable material in the bore-hole 13. The apparatus for forming the plug comprises a circular base plate 51 of wood or the like, having a center hole 52 through which shot-fire cables 15, 16, 17 (or other suspending means for the charges) pass. A vertically disposed tube 55 made of cardboard, plastic, metal or the like is fastened to the base plate and concentrically around the hole 52 and is of slightly larger diameter than the hole. A larger cylindrical member or casing 56 is fastened by means such as tacks 57, 58 (so that the fastening may be easily broken) to the base plate and extends upwardly therefrom. Conveniently, this outer tube or casing is a section of so-called "plastic" shot-hole casing.

A disk 59 of bronze screen or the like is fastened concentrically at the bottom of the base plate and is of larger diameter than the bore-hole so that when the apparatus is forced down the bore hole, the screen is bent upwardly on all sides and forms a temporary bottom form for a mass of wet concrete or the like, 60, held in the annular space between the two tubes above the base plate.

After the charges have been placed in the bore-hole, at their initial positions, the sealing apparatus illustrated in Fig. 4 is pushed down the hole by means of a loading pole 61 or similar device inserted within the inner tube. As shown in Fig. 5, this loading pole should have a section 62 cut from one side to leave space for the shot-fire cables passing through the tube. When the sealing apparatus has been pushed down the hole to a proper level, say slightly above the uppermost charge, the loading pole is jerked upwardly and the outer tube or casing 56 is broken loose from the base plate and pulled up out of the hole with the loading pole by means of cords 63, 64 fastened between the loading pole and the upper portion of the casing.

When the outer casing is withdrawn, the concrete (or other loose material) is free to flow outwardly against the wall of the hole and to settle against the screen disk. Preferably the concrete is of such consistency that it is easily handled and at the same time sufficiently fluid to flow tightly against the walls of the hole. Quick-setting cement should be used in the formation of the concrete so that the plug will set adequately in a short time, say less than two hours.

In the practice of that phase of the process of my invention which involves the movement of successive charges down the hole following the explosion of preceding charges, the several charges are pushed into the hole to appropriate levels by means of a conventional loading spoon or a series of conventional loading poles. The bore hole is sealed, either before or after insertion of the several charges therein, with a liquid, as for example, drilling mud.

It is desirable but not essential to provide all charges with an expansible device (for example that illustrated in Fig. 3) which tends to hold the charges in position and permits their movement down the hole when pressure or suction is exerted on them. After the charges have been placed (and spaced sufficiently from each other that explosion of a lower charge will not set off an upper charge) it is also desirable to form a plastic plug above the uppermost charge as described hereinabove. The use of the plug is primarily a safety measure.

When the charges and the plug are all in position, the lowest charge is detonated electrically. The resulting explosion forces the column of liquid or mud upwardly in the hole, and in many cases will cause liquid to be squirted out of the hole at the surface. As the column of liquid subsides, a strong suction is created on the upper charges. This suction usually lasts for several seconds, say 5 or 10. While this force is effective, the shot-fire cable holding the next lowest charge, say the charge 11, is released to permit that charge to be forced down the hole to a desired position, which may be the position originally occupied by the lowest charge. When the charge being sucked down the hole has reached the proper depth, it is held in this position by the shot-fire cable and the process is repeated, i. e., this charge is fired and the next lowest charged is lowered down the hole.

The explosions frequently tear fragments from the side of the bore-hole but these do not have a great opportunity to bridge or consolidate in the hole while the column of liquid or other fluid is moving violently therein and consequently seldom impede the passage of charges down the hole.

As indicated, it is not essential to the aspect of the process just described to use expansible apparatus on the upper charges or to employ the plastic plug. It has been found however, that both of these expedients are desirable not only as safety devices, but also because they appear to aid the carrying out of the process. Apparently the use of an expansible device which holds the charges off center in the hole facilitates their being pulled downwardly by the fluid column or by the vibrations set up by the explosion or both.

In the other aspect of the process, involving the explosion of a series of shots at predetermined locations vertically spaced from each other in the bore-hole, the use of the expansible devices on the upper charges is essential to prevent their upward displacement from their original measured positions by explosion of lower charges. But, as already noted, the expansible devices in such case need not be such as to permit downward movement of the upper charges following lower explosions, since no such movement is contemplated. Nevertheless it is convenient

to use that type of mechanism, the downward movement being prevented by tension on the shot-fire cables or the like. Accordingly, this aspect of the invention may be carried out with the apparatus illustrated in Fig. 1 and in the same manner, except that the shot-fire cables are not relaxed to permit the charges to drop when the "suction" resulting from the explosion of lower charges is imposed. Instead the shot-fire cables are kept tense to hold the upper charges in their initial positions.

The use of a plug may be eliminated in very deep bore-holes or whenever it appears that there is no hazard of an unexploded charge being blown to the surface.

As shown in Fig. 1, in a preferred practice of my invention, the charges are held off-center of of the vent in the plug so that, in the event of an accident and consequent movement of an unexploded charge up the hole, it will not strike the vent—an added safety feature. Quite aside from this feature, however, it is desirable to hold the charge against the side of the hole so as to increase the bearing surface and consequently the resistance to movement of the charge up the hole under the influence of a lower explosion.

I claim:

1. In an operation involving the drilling of a bore-hole downwardly in the earth, the loading thereinto of an explosive charge, and the explosion of the charge in the hole, the improvement which comprises loading into the hole a plurality of charges held vertically spaced from each other by a substantial distance, the hole being filled with liquid to a level above the uppermost charge, exploding the lower charge and immediately thereafter releasing and lowering the upper charge in the hole under the influence of a downwardly exerted force created in the lower part of the hole by the explosion of the lower charge the lowering of the upper charge being accomplished before the bore hole is clogged by debris resulting from the explosion of the lower charge.

2. Process according to claim 1 in which the movement of the upper charge down the hole following the explosion is controlled manually from the surface.

3. In an operation involving the drilling of a bore hole downwardly in the earth, the loading thereinto of an explosive charge and the explosion of the charge in the hole, the improvement

which comprises loading into the hole a plurality of charges held vertically spaced from each other by a substantial distance, disposing a plug in the hole above the uppermost charge, the hole being filled with liquid to a level above the uppermost charge, exploding the lower charge and immediately thereafter releasing and lowering the upper charge in the hole under the influence of a downwardly exerted force created in the lower part of the hole by the explosion of the lower charge, the releasing and lowering being accomplished before the lower part of the hole is clogged by the explosion of the lower charge.

4. In an operation involving the drilling of a bore hole in the earth and the explosion of charges therein, the improvement which comprises placing in the hole two charges spaced longitudinally from each other by a predetermined distance and sufficiently far apart that the explosion of one will not set off the other, holding the outermost charge in position in the hole by exerting pressure therefrom against the wall of the hole, the hole being filled with liquid to a point between the outermost charge and the top of the hole, exploding the inner charge, and immediately thereafter releasing the outermost charge and permitting it to be sucked into the hole before its path is clogged by debris resulting from the explosion of the inner charge.

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ADDITION OF A DESICCANT TO A FLUIDIZED IRON REDUCTION PROCESS

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The present invention relates to catalysts for the synthesis of hydrocarbons, oxygenated hydrocarbons and the like, from carbon oxide and hydrogen, and is more particularly concerned with the step of catalyst reduction.

In accordance with this invention, an oxidized metal of the iron group, such, for example, as ferric oxide or the like, usually associated with suitable promoters, activators, or other modifying agents, is reduced at elevated temperatures and preferably under superatmospheric pressure by contact with a stream of hydrogen. Reduction is carried out in the presence of a non-gaseous desiccant material effective to take up water promptly as it is produced in the course of reduction and thus enable the reduction to proceed in the absence of or in the presence of a substantially lower partial pressure of water vapor than that which prevails in the absence of the desiccant.

Advantageously, use of the desiccant material is postponed until later stages of reduction, when the reaction between the hydrogen and the remaining oxide becomes excessively slow and difficult. At this time, presence of the desiccant material in the reduction zone appears to speed and facilitate materially the sluggish reaction, substantially increasing the rate of catalyst reduction and resulting in a more completely reduced product. Presumably, this effect follows from the fact that water vapor tends to suppress reduction, while lower water vapor concentrations favor rapid completion of the reaction.

Provision may be made for continuously introducing a solid particle, desiccant material to the reduction zone as a finely divided phase suspended in the flow of hydrogen. As the hydrogen stream circulates cyclically through the reducing zone, the suspended particles absorb water vapor and pass out with the residual hydrogen withdrawn from the zone. Alternatively, a sufficient batch of relatively coarser particle desiccant may be retained in intimate admixture with the catalyst until completion of the reduction step, whereupon pneumatic separation may be effected by increasing the flow of reduction gas so that the hydrated desiccant is blown out of the zone. Obviously, in view of the foregoing, any other suitable method of separation may be employed.

The catalyst, reduced as above, is in a form effective for contact with synthesis gas comprising hydrogen and carbon monoxide, under reaction conditions, including an elevated temperature and pressure at which the hydrogen catalytically reduces the carbon monoxide with direct production of desired products, including hydrocarbons and oxygenated hydrocarbons. Preferably, however, such use of the catalyst is preceded by a conditioning treatment, such as is disclosed in copending application Serial No. 570,223, filed December 28, 1944, now U. S. 2,445,795, wherein use is initiated at a temperature substantially below normal operating temperature with a slow increase to operating temperature over a substantial time period.

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From the foregoing it will be apparent that an essential characteristic of the present desiccant material or dehydrating agent is that it readily combines with water at the elevated temperature and pressure at which reduction is effected, to form a compound or compounds stable under such conditions. In short, the dissociation pressure of the compound formed by combination of the desiccant with water is lower, at the temperature prevailing in the reduction zone, than the partial pressure of water vapor which would prevail in ordinary operation, preferably less than that partial pressure of water vapor in the gases after condensation at pressures in the order of 100 to 400 pounds per square inch, and at normal temperatures of about 100° F. and preferably about 70° F.

Another desirable feature of the dehydrating agent is that, during the course of hydration, it advantageously tends to disintegrate or crumble into smaller, fluffy particles which can be readily removed from the catalyst by ordinary separating steps or can be swept out by a slight increase in the upflow of gases.

Examples of effective desiccant materials are carbides of aluminum and particularly alkaline earth metals, such, for example, as calcium carbide and barium carbide, which combine chemically with water vapor to form corresponding alkaline metal oxides and liberate gaseous acetylene. The carbides of the rare earth metals are also useful in this respect. On the other hand, metal hydrides, such for example, as calcium or barium hydride, are similarly effective to combine with water vapor, simultaneously liberating additional hydrogen to supplement the stream of reducing agent. It is to be noted that substances such as calcium oxide, barium oxide and magnesium oxide, which chemically combine with water to form the hydroxides and substances such as calcium sulfate and the perchlorates of magnesium and barium which form hydrates, are also useful as desiccants in the present process.

Agents which remove water by chemical combination are, in general, more suitable for use in

reduction steps carried out at relatively high temperatures, as for example, in the range of about 600 to 800° F., as contrasted with those which form hydrates, which are usually effective at lower temperatures, for example, below about 400° F. That is to say, compounds that are formed by chemical interaction of the water and desiccant are more stable since they require higher temperatures to convert them to their anhydrides.

The reduction of the catalyst contemplated, in accordance with the present invention, may be carried out at the lower temperature ranges, but is preferably effected in the case of a catalyst comprising iron, at temperatures ranging above about 600° F., as for example, 650 to 700° F., frequently under more elevated temperatures up to 1000° F. and above, usually under superatmospheric pressure, ranging, for example, up to 200 to 400 pounds per square inch and normally is accompanied by formation of substantial amounts of water.

As the reduction approaches completion, the reaction slows considerably in the presence of only small proportions of water vapor. Accordingly, even where the hydrogen is continuously passed through the reduction zone, withdrawn, dried and recirculated, at substantial rates, completion of the reduction requires excessive time and results in an uneconomical loss of highly diffusible hydrogen. This follows from the fact that dry hydrogen introduced to the zone is promptly contaminated with product water vapor.

Therefore, the present invention effects a substantial increase in rate of reduction by the removal of water vapor as it is formed so that the partial pressure of water vapor is substantially lowered in the reduction zone. Thus the decrease in the reduction rate normally encountered toward the end of the operation is overcome. This permits reduction at lower temperatures and at lower rates of hydrogen circulation of the reducing gas than hithertofore. Therefore, the preparation of substantial quantities of catalyst may be effected with a more economical utilization of hydrogen and less loss of time, and the final product may be more fully and completely reduced. In particular, the saving in hydrogen lost by diffusion during more extended treatment may involve a substantial economy in operation.

As intimated above, it is contemplated employing the desiccant in solid particle form, preferably in the form of powder or within the same or similar particle size range as the catalyst particles so that intimate contact is effected within the reaction zone.

The catalyst powder is usually in the form of a mass of solid particles disposed loosely within the zone and preferably aerated to a dense fluid phase by means of the upflowing reducing gas. The invention, however, is not thus limited, and broadly contemplates the reduction of any suitable synthesis catalyst, whether in the form of fluid or stationary bed of fixed particles. In the fixed bed type of operation, or even with so-called "moving" beds of catalyst, the particles may be in relatively coarse form, providing substantial internal free space through which a finely powdered desiccant will flow when suspended in the reducing gas.

In either case, introduction of desiccant particles as a suspended phase entrained in the reducing gas results in immediate distribution and intermixture of the desiccant with the mass of catalyst particles. Operating in this manner, separate provision for mixing and distributing the desiccant in the catalyst powder is obviated.

As intimated above, the rate of gaseous flow through the fluid phase catalyst mass, and degree of subdivision of the desiccant powder may be regulated so that the catalyst particles remain within the reduction zone while the desiccant is withdrawn with the effluent hydrogen. This can be effected with the catalyst in either dense fluid phase, or fixed bed condition. Or, somewhat larger particles of desiccant may be retained in the zone, at least until the particles have completed chemical reaction with the water vapor and assume a more buoyant condition at which they are entrained in and removed in the circulating flow of reducing gas.

Alternatively, a stoichiometric quantity of desiccant may be mechanically mixed with the catalyst and the reduction completed under flow rates at which entrainment of solid particles is negligible, and thereafter, the flow rate increased to a value at which the more buoyant desiccant particles are in effect blown out of the catalyst.

Provision may be made for filtering, electrostatically separating or otherwise removing particles from the effluent hydrogen. Similarly, any conventional means of separation may be employed to recover desiccant solid from the treated catalyst. For example, magnetic separation affords an effective means whereby the final reduced catalyst is preferably rendered substantially free from the added solid desiccant.

In accordance with one method of operation, a stream of hydrogen is continuously passed through a mass of iron oxide powder, comprising mainly Fe_3O_4 and Fe_2O_3 finer than about 50 mesh and containing a more or less uniform distribution of particles down to about 20 microns in diameter. Preferably, the hydrogen is passed upwardly through the mass at a temperature of about 700° F. and at a suitable linear velocity such that the catalyst particles are held in a dense fluid phase without material entrainment in the effluent gas. Unconsumed excess hydrogen is withdrawn from the top of the dense fluid phase, cooled to condense contained moisture and separated from the condensed water. Thereafter, it is usually continuously reheated, and continuously recycled to the inlet with an appropriate supplement of fresh hydrogen to maintain the required flow.

Under these conditions, reduction of the catalyst proceeds at a fairly rapid rate until somewhat above about 80 per cent of the oxide has been reduced to metallic iron.

At this point, a batch of powdered calcium carbide is thoroughly mixed with the catalyst in at least the stoichiometrical proportion effective under the temperature and pressure conditions prevailing to absorb the water vapor formed during subsequent reduction. Recirculation of the hydrogen is continued as before, until at least 95 and preferably 100 per cent of the catalyst has been completely reduced, and the desiccant is then separated from the catalyst by any desired means.

In accordance with one specific embodiment of the present invention, there is provided about 750 pounds of an alkali impregnated ferric oxide finer than 35 mesh, about 80 per cent being finer than 100 mesh, and about 30 per cent being finer than 325 mesh.

The ferric oxide contains approximately 2 per cent alumina and about 1 per cent potassium,