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(54) Title: ELECTRO-SEPARATION OF OIL-BASED DRILLING FLUIDS

ELECTRO-SEPARATION OF OIL-BASED DRILLING FLUIDS

The present invention relates to an apparatus and method for separating oil-based drilling fluids from all-oil drilling muds and invert muds and more particularly to a method and system that uses electro-separation.

BACKGROUND

Invert emulsion drilling fluid (commonly called drilling mud) is used when drilling boreholes in the ground, such as for drilling oil or gas wells, etc. It is typically pumped through the drill string and out a nozzle on the drill bit during the drilling of the hole so that the drilling fluid can keep the drill bit cool and carry rock, clay and other solids (commonly referred to as cuttings) removed from the well by the drill bit up the annulus of the well and back to the surface.

Invert emulsion drilling fluids are typically water based or oil based. Oil based muds usually contain oil in the form of a petroleum product similar to diesel fuel. In addition to the oil, these oil based drilling fluids can also contain viscosifiers, weighting agents and other filtrate control additives. To remove the cuttings from the drilling fluid that has been returned to the surface, solids control equipment in the form of shakers, conveyors, centrifuges, etc. are used to remove the majority of the native clays or drill solids that make up the cuttings.

However, these solids control equipment are not designed to re-capture the base oils necessary to create the drilling fluids. It is the presence of hydrocarbons which are physically and chemically bound to the fines, as well as additives, that make separation and recapture through conventional means difficult.

SUMMARY OF THE INVENTION

The following is considered as illustrative only of the principles of the invention. Further, since numerous changes and modifications will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all such suitable changes or modifications in structure or operation which may be resorted to are intended to fall within the scope of the claimed invention.

DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the present invention is described below with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of an apparatus for separating oil-based drilling fluid; and

FIG. 2 is a perspective view of the apparatus shown in FIG. 1 with an electrode plate removed.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

FIGS. 1 and 2 illustrate a separation apparatus 20 for removing hydrocarbon from cuttings (including fines and rock solids) from oil based drilling muds. Electrokinetics in conjunction with mechanical pneumatic vibration is used to influence the movement of hydrocarbons within the drill fluids. Direct current (DC) electricity provides the primary force in the form of electrokinetic phenomena and the mechanical hydraulic vibration is used to address the removal of the native clays / drill solids from the drilling fluid, degassing the electrified plates and assisting in collection of the drilling fluids. By using the apparatus 20 to apply an electrical field to a volume of oil based drilling mud in order to segregate the hydrocarbon from the drilling fluid and corresponding clay fines, a hydrocarbon supernatant is formed that is clear of solid particles.

The apparatus 20 can include a housing 1 and a set of parallel electrode plates 2. The electrode plates 2 can be formed of stainless steel, carbon steel or aluminum. The electrode plates 2 are insulated from the housing 1 by the use of an ultra-high-molecular-weight polyethylene (UHMWPE) liner 4. Each of the electrode plates 2 can be a plate that extends from one end of the housing 1 to an opposite end of the housing 1. In one aspect, the electrode plates 2 can be flat. In other aspects, the electrode plates 2 may be corrugated. When they are positioned in the housing 1, the electrode plates 2 can be provided parallel to one another and oriented vertically so that a spacing is formed between adjacent electrode plates 2. In one aspect, the spacing between adjacent electrode plates 2 could be between 0.25 inches and 1.5 inches. Each electrode plate 2 can have an ear 15 that extends above drilling fluid when the drilling fluid is provided in the housing 1.

The electrode plates 2 can be connected via a top mounted bussbars 5A, 5B. Typically, the bussbars 5A, 5B are connected to the electrode plates 2 by the ears 15 on the electrode plates 2. Every other electrode plate 2 in the set can be connected to a first bussbar 5A and the remaining electrode plates 2 are connected to the second bussbar 5B. This can be achieved, in one aspect, by having the ears 15 of every other electrode plate 2 aligned on one side of the housing 1 and connected to the first bussbar 5A and all the remaining electrode plates 2 having their ears 15 aligned and positioned on an opposite side of the housing 1 to be connected to the second bussbar 5B. The bussbars 5A, 5B can be wired to a DC power supply so that every other electrode plate 2 is positively charged by applying a positive voltage to the first bussbar 5A and the remaining electrode plates 2 are negatively charged by applying a negative voltage to the second bussbar 5B, creating a circuit between the electrode plates 2 and generating the applied field strength across the electrode plates 2.

Vibrator(s) 17 such as a pneumatic hammer can be provided in physical contact with the electrodes plates 2 so that the vibrators 17 can be used to vibrate the electrode plates 2.

For removing fluid from the housing 1 after the separation has occurred, a number of outlet ports 7A-7M can be provided in a wall 22 of the housing 1. These outlet ports 7A-

7M can be provided at various heights along the wall 22 of the housing 1 so that they can be used to remove various layers of the separated fluids. A hopper 8 can be provided on a bottom of the housing 1 so that solids that settle in the housing 1 collect in the hopper 8. A drain port 9 can be provided so that solids and fluid that have collected in the hopper 8 can be removed through the drain port 9.

The apparatus 20 can be capped so that a headspace 25 above the electrode plates 2 in the housing 1 is sealed, preventing air and other gases from entering and exiting the top of the housing 1. A blanket of nitrogen can be provided in this headspace 25 to prevent an buildup of oxygen in the headspace 25 as a result of anode/cathode reactions occurring in the housing 1 and allowing the apparatus 20 to meet a 'Type X' designation so that it may be used in hazardous environments. The headspace 25 inside of the apparatus 100 can be continuously monitored by an oxygen sensor 10. If the oxygen sensor 10 determines that the level of oxygen in the headspace 25 reaches an undesired level, more nitrogen can be routed into the headspace 25 in order to reduce the oxidizing agent level and eliminate a possible explosion in the headspace 25.

In operation, drilling fluid is introduced into the housing 1 between the parallel electrode plates 2. An electric field can then be generated between the electrode plates 2 to subject the drilling fluid in the housing 1 to a first electro-separation stage. A DC voltage can be applied across the electrode plates 2 to create an electric field between the electrode plates 2 that passes through the drilling fluid in the housing 1. In one aspect, it has been determined that using an amperage of approximately 0.1 Amperes is sufficient to cause electro-separation of the drilling fluid. In another aspect, the current used may be in the range from 0.1 Amperes to 10 Amperes. In one aspect, the current being passed between the electrodes plates 2 can be maintained at a substantially constant level, while the voltage is slowly varied to keep the current substantially constant.

The electric field applied between the electrode plates 2 can cause the separation of the drilling fluid through the use of the process of electrokinetics to destabilize the bonds between the hydrocarbon, the fines and other cuttings and the drilling fluid. Electrokinetics involves the processes of; electrophoresis, dielectrophoresis, electromigration and electroosmosis. Electrophoresis is the primary phenomenon which occurs in the drilling fluid. Electrophoresis involves the movement of charged particles through a fluid medium under the influence of an electrical field. This process acts to reduce ultra-fine clay particles in the drilling fluid. Dielectrophoresis involves the movement of uncharged particles under a non-uniform electrical field. This is dependent on the fluid medium, particle properties, particle size and gradient of the voltage field. Electromigration involves the movement of ions towards the electrodes of opposite charge. The electric field destabilizes the emulsion, allowing hydrocarbons to be released. Electroosmosis involves the movement of water from anode (+) to cathode (-). Applied DC current breaks any bonds that water may have with other particles and allows it to migrate within the drilling fluid.

During this first electro-separation stage, the electric field can be maintained for a period of time, allowing the electrokinetic effect to act on the drilling fluid and the hydrocarbon to separate from the fines and cuttings. In one aspect, this could be a few hours or more, however, the amount of time will vary on the size of the housing 1, number of electrode plates 2, amount of drilling fluid, etc. As the electric field continues to be passed through the drilling fluid, hydrocarbon will rise to the surface of the drilling fluid.

After the period of time, subjecting the drilling fluid to a short vibration stage by using the vibrator 6 to vibrate the electrode plates 2. This can exacerbate the fluid medium into a highly vibratory state in order to release and free fluid that is trapped throughout the medium or that has collected along the electrode plates 2 because of high surface tension.

Additionally, the vibratory effect created by the vibrator 6 can provide cleaning benefits for the electrode plates 2 themselves. By vibrating the electrode plates 2, particles that have started to form on the surface of the electrode plates 2 can be vibrated loose from the electrode plates 2. By reducing the amount of particles that form on the electrode plates 2, a stronger electrical field can be maintained through the drilling fluid.

After the vibration stage, the polarity of the electrode plates 2 can be reversed and the fluid in the apparatus 20 can be subjected to a second electro-separation stage. If a positive voltage had been applied to the bussbar 5A and a negative voltage applied to the bussbar 5B in the first electro-separation stage, this can be reversed for the second electro-separation stage, and vice versa. By reversing the polarity, the electrode plates 2 that acted as the anodes during the first electro-separation stage will now act as cathodes and the electrode plates 2 that acted as cathodes during the first electro-separation cycle will now act as anodes. Reversing the polarity of the electrode plates 2 for the second electro-separation stage can provide benefits with respect to preventing possible electroplating of the electrode plates 2 and maintaining a maximized electrical field. If the same electrode plates 2 always act as cathodes, particles can build up on these electrode plates 2.

The second electro-separation stage can be maintained for a set period of time (in some cases this may be a few hours or more depending on the size of the electrode plates 2).

During the first electro-separation stage and the second electro-separation stage, the drilling fluid will separate into a number of stratified layers in the housing 1. An upper stratification layer containing a high concentration of hydrocarbon will rise to the top of the housing 1 and collect on the surface of the drilling fluid 1. Below the upper stratification layer, a medium stratification layer will occur. This medium stratification layer will contain a low percentage of particles (fines and cuttings). The separation of the upper stratification layer and the medium stratification layer suggests that the two layers have varying densities. Below the medium stratification layer will lay a lower stratification layer. The fluid mass layer contains highly viscous semi-consolidated invert drilling fluid mass. The majority of the fines and cuttings from the drilling fluid along with the any thickening agents (barite) will likely be contained in this fluid mass layer.

After the second electro-separation stage, the upper stratification layer can be removed from the housing 1 via the appropriate ports 7A-7M located along one wall 22 of the housing 1. In one aspect, fluid can be continuously drained and collected from the ports 7A-7M in a separate container (not shown) until the highly viscous upper stratification layer changes in consistency. The medium stratification layer can then be collected in a separate container (not shown) until the highly viscous semi consolidated mass began to leach out. The lower stratification layer can also be drained from the housing 1 using the appropriate ports 7A-7M.

The lower stratification layer will sink to the bottom of the housing 1 and will collect in the hopper 8. The lower stratification layer can be drained from the housing 1 using the drain port 11 provided in the hopper 8.

During the separation of the drilling fluid by the apparatus 20, the oxygen level in the headspace 25 can be monitored continuously using the oxygen sensor 10. If the oxygen level rises above the desired level during the separation of the drilling fluid, nitrogen can be introduced into the headspace 25 creating a nitrogen blanket, reducing the oxidization agent and eliminating the possibility of an explosion in the headspace 25.

The apparatus 20 can produce hydrocarbon from the drilling mud at an extremely high rate (50% or greater) in comparison to the original invert drilling fluid, therefore reducing the disposal volume considerably. Through the removal of ultra-fines and additives from drilling fluids, the density and viscosity of the fluid is decreased, while the relative hydrocarbon content is increased. This reduces the excessive dilution required when reconditioning drilling fluid and effectively extends the life cycle of the drilling fluid. The apparatus 20 reduces waste disposal volumes and associated costs meeting both operational and environmental goals.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous changes and modifications will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all such suitable changes or modifications in structure or operation which may be resorted to are intended to fall within the scope of the claimed invention.

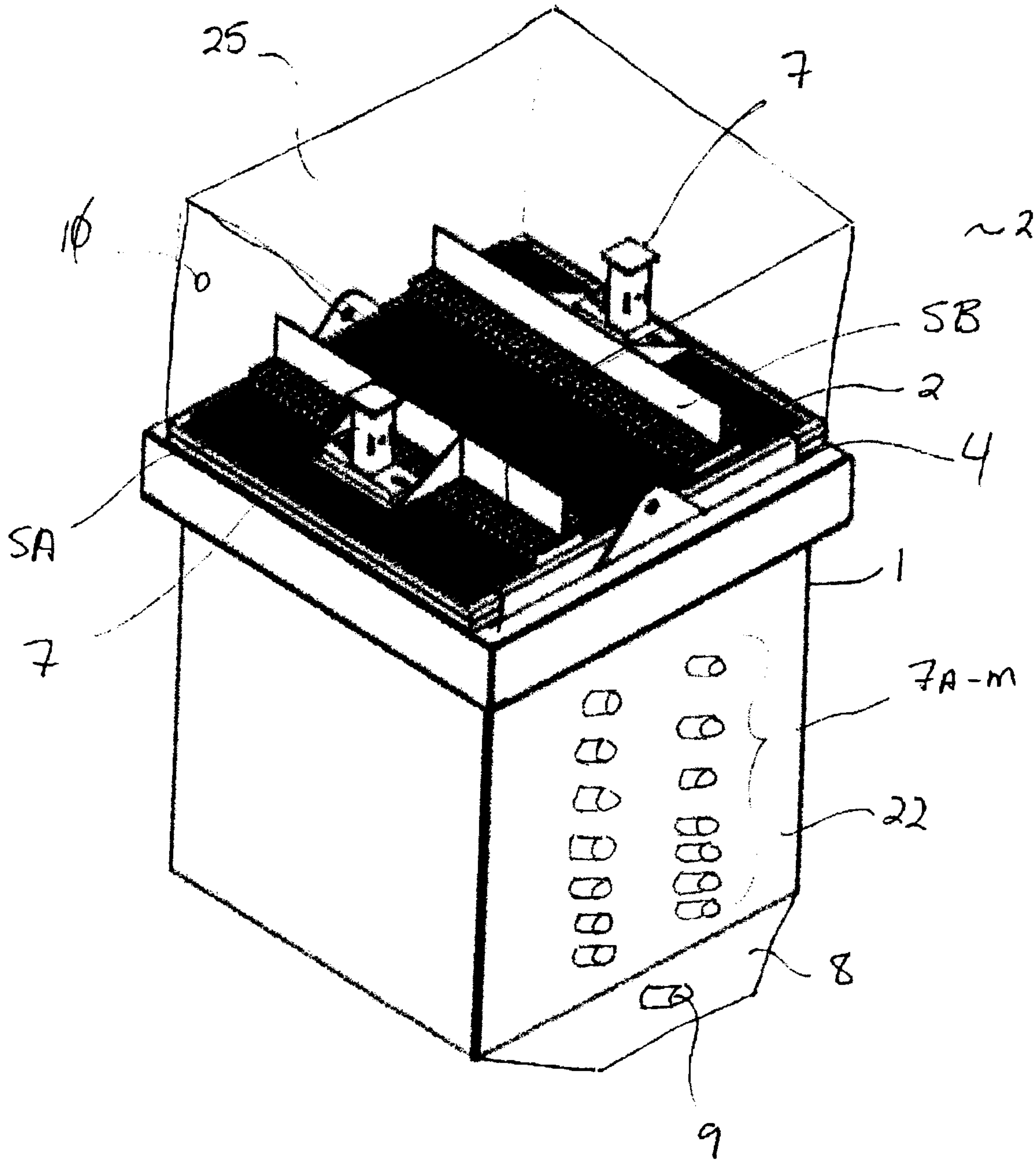

FIG. 1

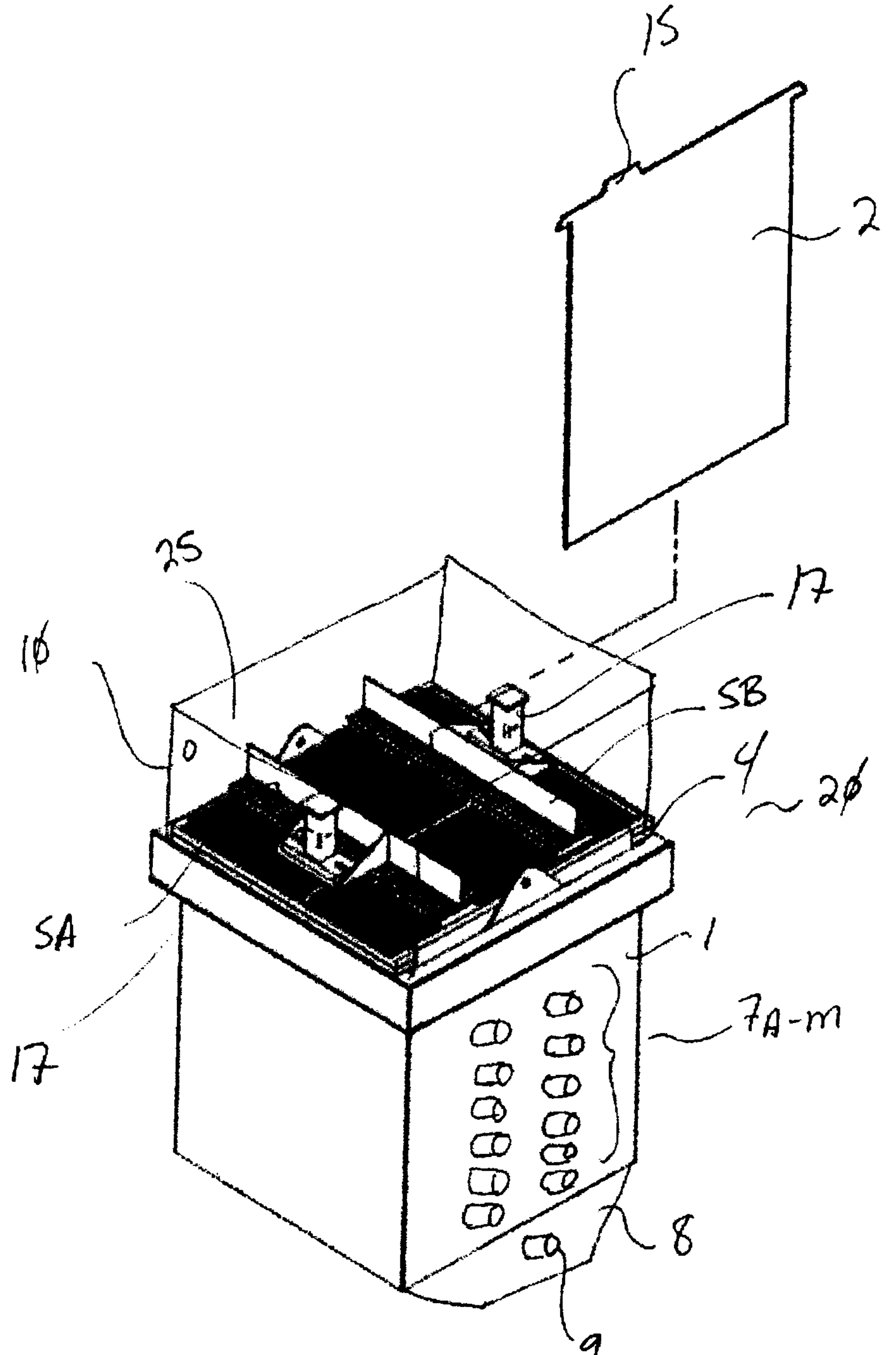

FIG. 2