This invention relates to a process for sealing off water behind casings in wells and cementing pipe so as to prevent migration of underground water between upper and lower portions of the well hole.

The invention more particularly relates to the use of a liquid material comprising a modified sodium silicate which by neutralizing, mixing or associating with acids or salts will form a gel material which solidifies in the space between the casing and the well bore and will prevent the flow of water from water formations into the oil-bearing or producing formation.

Moreover, this application is a continuation-in-part of our previous application Serial Number 208,933, filed May 19, 1938, wherein the liquid gel material is disclosed for sealing off formations encountered in the drilling of wells but before the well bore has been cased.

The exclusion of water from oil bearing formations is a matter of the gravest importance, not only to the owner of a well in which water may appear but also to the holders of surrounding leases. Water may be frequently encountered in drilling and if it is admitted to the oil sand, permanent injury to the well and adjacent territory inevitably follow. Water entering a leaky casing seat gradually cuts a channel which admits increasing quantities as and if this attains ample volume and reaches a sufficient level in the well, the oil will be drowned or pushed back laterally by reason of the greater specific gravity of water, perhaps permanently ruining the well and flooding a portion of the adjacent territory.

Also, water from different formations usually differs in the amount of dissolved materials in said waters, said materials being salts such as sodium chloride, calcium chloride, etc. This difference in amount and quantity of dissolved salts causes a difference in potential between the water producing formations. When the casing is in contact with these waters, it completes the circuit for a concentration cell which condition is a well known source of corrosion. The casing thus becomes perforated and allows the waters to enter the well bore through the perforations or corroded spot in the casing.

The exclusion of water by the cementing process, while involving considerable expense and delay, is probably the most satisfactory in regions where wells of large capacity are encountered and a permanent solution of the difficulty is desired. In other fields water is promptly, economically and effectively excluded by means of packers lowered on either casing or tubing. In the older fields of the United States the packer method is the one generally used, about thirty types of improved packers now being manufactured to meet the varied requirements. In known regions where wells of large capacity or high pressure are anticipated or where the exclusion of water is difficult, it is customary to cement the water string of casing in the most suitable formation between the oil sand and the last water bearing stratum encountered above it. The object sought in cementing is to construct a water tight barrier between the exterior of the lower portion of the casing and the wall of the well in order to exclude from the drill hole all water previously encountered.

The primary object of this invention is to introduce a liquid gel forming material, either with or without a filler being added, into the space between the well bore and the casing in such a manner that a gel by neutralization, mixing or association will be formed, thereby plugging the space between the well bore and casing to prevent water from coming into contact with the casing and further to prevent seepage of water into the oil bearing formation from water formations located above the same.

A further object of the invention is to provide a gel forming material which prevents contact between the casing and the source of corrosive water and further acts as an electrical insulating material so that the iron casing cannot serve as a conductor in completion of a circuit in a concentration cell.

A still further object of this invention is to provide a resinous or gel forming material which is non-porous and will not permit the seepage of water, also presents a lighter material to pump than a slurry of cement, and more effectively fills the void spaces.

A still further object of this invention is to provide a gel forming material which has the advantage of remaining liquid until it is in place and the setting time may be varied or controlled from a few minutes to several days.

Other objects and advantages will appear to those skilled in the art from a careful study of the description to follow.

The most desirable gel is formed from Baumé sodium silicate diluted with 1 to 3 parts water and neutralized or associated with acids or salts which will cause sodium silicate to form a gel. The diluted sodium silicate is poured into an equal volume of the neutralizing agent with enough agitation to prevent precipitation. Hydrochloric acid is the acid recommended for use.
reliability in oil field districts and since it is the most inexpensive but other acids will form the same type of gel. The acid materials form the best and most controllable gels but the mixture must be inhibited to prevent corrosion in the tubing and casing. The acid gels do not precipitate in brine as do the alkaline gels but the fact that the alkaline materials precipitate upon coming into contact with brine need not exclude it from being used as the alkaline gels are nearly as corrosive as the acid gels even when the acid is inhibited.

Mud or fibrous materials may be added to the gel forming liquid in order to prevent cracking 15 and to make the sealing material less expensive. The mud may be selected from any of the commercial drilling muds or natural clays that do not react with the silica gel. "Aquadag," a product marketed by the Baroid Sales Company and containing clay products of which one is bentonite has been found very suitable as a filler material because it does not settle out and a large portion may be added to the gel forming liquid without making the finished product too viscous to pump. Materials such as wood fiber or commercial material products like bagged sugar cane fibers make a suitable filling agent. Carbon black has also been found to be a very desirable and economical filler for the liquid material. It is to be understood that the liquid gel material would function just as well with the filler material omitted but for the sake of economy and to make the use of the material competitive with cement slurry, it may be necessary to add a filler.

Sodium silicate has heretofore been employed as a sealing or plugging agent to shut off gas or water bearing formations in the drilling or producing oil wells. The trouble experienced in the use of sodium silicate was the fact that the sodium silicate would set up solid in the presence of the salts normally present in the brine encountered in wells. This did not allow sufficient time to get the sodium silicate into the formation to be plugged before it set and hence made the product practically worthless as a plugging agent. Applicants have found that the setting or solidifying action of the sodium silicate can be delayed by the addition of acid or salts and has made use of this knowledge in using the resulting product in sealing off water behind casings in wells and cementing pipe in wells where brine is present. It is found that the acid and salts retard or delay the action of the salts in the brine on the sodium silicate gel material to the point where the material can be pressured behind the casing or pipe to be sealed before the same sets up as a gel or solid mass.

Other examples of mixtures which may be used will follow:

A sealing agent made from 50 parts 41 Baumé "N" brand sodium silicate in 50 parts water mixed with 100 parts inhibited 7 hydrochloric acid. The diluted sodium silicate is poured into an equal volume of the hydrochloric acid with enough agitation to prevent precipitation. Any desired filler is stirred into this liquid mixture until it approaches the viscosity that will not be a pumpable mixture. This material becomes solid after three hours at room temperature.

Another gel applicable to the present process is made as follows: 41 Baumé "N" brand sodium silicate is diluted with 50 parts water and poured into 100 parts 3.5% sodium aluminate with enough agitation to prevent precipitation. Any desired filler, preferably carbon black, is added with stirring until the mixture approaches the viscosity which would not be a pumpable mixture.

The gel forming material is applied to the well hole in a manner similar to that used in cementing well casing with cement and the use of the material is to be as a substitute for the presently used cement slurry. The gel forming material 10 in a liquid state must be lowered to the bottom of the well bore within the casing, after which the column of casing is raised a few feet and by mechanical means the material is then forced upward into the annular space between the casing and the surrounding wall and thence allowed to solidify. The material may be dipped in the bottom of the hole from a bailer and pressure applied by wooden plugs or any other pressure means available to force the material into the space between the casing and bore wall. The two plug method wherein the material is placed in the casing between two wooden plugs and pressure then applied on the top plug may be employed to get the material into the desired space. The behavior of the material in the liquid state is identical with the behavior of cement slurry and both are adaptable to the same methods for getting the material back of the well casing.

The present gel forming material presents advantages over cement slurry in that the time of set can be controlled; when set, the material is nonporous, it is more resistant and will withstand shock better especially when the well is shut in and further there is a better cohesion between the material and bore wall and the material and casing. Applicants lay no claim to presenting a new method of getting the gel forming material into the desired space and present a new method of sealing off the space between the bore wall and the casing.

In conclusion, our invention specifically relates to the use of liquid gel forming materials, with or without a filler added, wherein the chemical reaction is definitely controlled so as to produce a solid mass or body within a controlled time limit which allows sufficient time to prepare and introduce the liquid resinous or gel forming material into a well before the same gels or solidifies. Certain chemical materials which will react in this manner have been specifically mentioned but it is to be understood that other compounds or mixtures containing the same physical and chemical properties as those specifically mentioned will react in the same manner as those mentioned and that various changes in the choice and amounts of materials used can be made without departing from the spirit of our invention or the scope of the subjacent claim.

We claim:

A process for plugging and sealing the space between the well bore and a string of casing which comprises the step of introducing into the space a liquid gel forming material comprising a mixture of 50 parts sodium silicate diluted in 50 parts water mixed with 100 parts hydrochloric acid and carbon black added to the mixture as a filler and allowing the mixture after in place to undergo a chemical reaction to form a solid mass.

WILLIAM BRUCE LERCH.
CLYDE H. MATHIS.
EUGENE J. GATCHELL.