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**« The Basgan Effect » and its  
Application in the Drilling  
Technology for the Exploitation of the  
Underground  
Energy**

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## Historical presentation

The United States is the country from which Rotary drilling spread throughout the world.

In two decades man has conquered space. However, as regards the interior of the Earth, in 2000 years Man has not been able to penetrate more than 5 miles of the globe's total radius of about 4000 miles. At that depth, technical science reached a critical limiting point.

Modern technology has succeeded in overcoming the Earth's gravitational field and surpassing the speed of sound, but has not been able to overcome the hardness of the Earth's shell (lithosphere) and hydrostatic pressure at great depths.

Romania was the country where the exploitation of petroleum deposits began back in the 17<sup>th</sup> century.

Bucharest was the first capital in the world which was illuminated with petroleum distillate. This was instituted in 1857 by the Mehedințeanu Company.

At that time, 1857, Colonel Drake in America began drilling the first well in Titusville, Pennsylvania, the success of which represented the beginning of the gigantic development of the oil industry in the United States.

The science and technology of oil drilling underwent a great development in Romania in the period between the First and Second World Wars. The Romanian oil fields became the forum and the training grounds of the world's petroleum drilling technologists. Therefore, during this period, I personally met in Romania many American petroleum engineers. For example I can mention Mr. Fair and Mr. Guess, under whom I began my engineering work.

During this period, throughout the world, vertical drilling was not used because the technique for vertical drilling was not known. For that reason, in Romania, research facilities were instituted by me to discover scientific and technical reasons why vertical drilling had been unsuccessful. I concluded that vertical drilling had failed because Archimedes' Principle had not been considered, and secondly that this principle had not been adapted for great depths.

At the first World Petroleum Congress in London, which took place in 1933, I attracted much attention by the presentation of my paper entitled : « Scientific Considerations on Moderne Drilling Techniques », which included the scientific importance of Archimedean pressure and which also discussed the possibility of long distance transmission of sonic energy, from the surface, through the drilling string, to the bit.

At the World Petroleum Congress in Mexico City in 1967, it became evident that the 5 miles limitation on drilling had become obsolete and the future of drilling technique would depend on simultaneous rotative and percussive drilling, described and patented by me in Romania in 1934 and in the U.S.A. in 1937.

Professor Rene Navarre, president of that Congress in Mexico City and also of the French Petroleum Institute, emphasized both at the beginning and at the conclusion of the Congress that drilling technique had been developed mostly empirically and not sufficiently scientifically, and observed that it would be necessary to work more scientifically, just as I had pointed out during the first Congress in London in 1933.

#### **NEW STATEMENT AND INTERPRETATION OF ARCHIMEDES' PRINCIPLE AND ITS APPLICATIONS IN MODERN DRILLING**

World technical progress has needed an increased petroleum production, and because of this, in order to ensure a steadily growing production, better drilling techniques were developed.

At the beginning of the twentieth century, rotary drilling became the leading drilling technique throughout the world, due to the possible mechanical speed, but the holes were sometimes seriously crooked, requiring costly fishing jobs and some of them were unsuitable from the technical point of view.

The behaviour of deformable bodies composed of tubular materials and sucker rods, used in drilling, and producing oil wells, creates difficult and delicate problems from the practical, technical and economic point of view. This is because, unlike the surface operations, these bodies get in the bore hole in static or dynamic contact with various effects and laws of physics under conditions completely beyond the conditions under which these have been studied and formulated.

After the First World War, the number of rotary drilling wells increased rapidly and in the drilling technique, the causes of the deviations were investigated and also the possibility of drilling straight holes.

All the now innovations in connection with the manufacture of special tools, reamers, etc., did not overcome the difficulties in obtaining straight holes.

During the period of 1925-1934, I researched the causes of hole deviations, succeeding in solving the problem only by abandoning the

classical principles of the hydrotechnics and drilling techniques of that time.

#### Short history of the proportional drill-collar problems

The discovery of new sciences and techniques is often impeded and delayed by the inertia of old traditions.

During the last four decades, wells drilled into the earth's crust have progressed, advancing from 2 miles to 5 miles in depth.

The drilling string works in a fluid medium and its behaviour and composition is analysed according to the classical Archimedes' Principle, which was made two thousand years ago.

Here is the principle enunciated by Archimedes as expressed in « La grande Encyclopédie » - Paris :

« Any solid immersed in a liquid receives from part of this liquid a vertical thrust directed upward and equal to the weight of the fluid which it displaces.

The point of application of this force is at the center of gravity, not of the solid itself, but in the center of gravity of the liquid mass of the same shape as the solid displacing it.

These two centers of gravity coincide when the solid is homogeneous.

Generally the center of thrust is considered to be at the center of gravity of the supposedly homogeneous solid. At this point the liquid force is applied. »

On the basis of this enunciation there was introduced into hydromechanics the principle of apparent weight.

The loss of the drilling string's stability and the crooked or Spiral holes in drilling could not be remedied, owing to the use of classical principles of hydromechanics, which did not permit us to find the real causes of these deficiencies.

The upsetting of certain classical traditions led to the discovery of new ways in hydrotechnics and in drilling technique and implicitly to the finding of the factors which cause the hole irregularity and after that to the use of new drilling methods in which I have improved rapid vertical drilling with proportional drill-collars.

According to the classical theories, the drilling string immersed in the drilling fluid was considered as if it had a new specific weight (equal to the difference between the specific gravity of the steel and of the drilling fluid), named « apparent weight ».

During the period 1925-1934, while drilling numerous wells of Romania in Moreni Gura Ocnitei, Scaiosi, Ceptura and Moinesti oil field and while trying to find the cause of well deflections, I arrived, first practically, and afterwards theoretically, at the conviction that the drilling string is pushed upwards by the force of buoyancy and unlike previously known principles, the application point of this force is precisely on the lower surface of the drilling string at the bit, and not in the gravity center of the drilling string.

This led to a new explanation of the application and enunciation of Archimedes' Principle, adapted to the specific case, which revolutionized drilling technique.

Because the point of application of the buoyancy force is at the lower part of the drilling string, I discovered and then calculated the existence of the compressed zone and of the neutral zone, called, now in scientific circles the **Basgan Effect**.

At the first World Petroleum Congress in London, 1933, I showed scientifically the path of transmission of the propelling force through the drilling string from the surface to the bit, and the existence of the vibrations in the drilling string, calling attention to the importance of the Archimedean force in drilling technique and the modifications introduced by me in the point of application of the hydrostatic force of the drill-hole liquid.

#### Rotary drilling methods with proportional drill-collars

My new scientific discoveries then led me to the solution of the problem of well deviation on both industrial and technical planes.

It was necessary to lower the neutral zone and to avoid compression in the drill pipe.

Thus I introduced the proportional drill-collars equal in weight to the force which acts upwards at the lower end of the string, plus the weight necessary to be put on the bit.

Field experience in this line confirmed my theory and I registered these inventions on May 18<sup>th</sup> 1934 in Romania under Patent No. 22789 and in the U.S. (under Patent No. 2103,137) 1937.

To sum up, I reached the conviction, which I then proved, that the hydrostatic pressures create a resultant force which acts upwards in an opposite direction to gravity and I introduced in drilling technique the proportional drill-collars equal in weight to the drilling pressure on the bit plus the buoyancy force. By doing so, the neutral zone was lowered from the drill-pipes to the drill-collars, eliminating the compression stresses from the drill-pipes.

The proportional drill-collars attain a total weight of 10 to 30 tons ; they increase proportionalelty, depending on depth and on the

displacement of the drilling string, but the drilling pressure on the bit depends on the drill-collars only.

In the patents I showed that, in addition to the necessary drilling pressure on the bit, a new weight must be introduced, which will vary proportionally as the total weight increase of the drilling string when immersed in the fluid, with the principal object of neutralizing the resultant hydrostatic pressure, which acts directly on the lower end of the drilling string.

« This resultant buoyancy, if not counteracted, would work in the opposite direction opposing the entry of the bit into the deposit, and would have an unfavorable effect on the drill pipe's strength and would cause a series of difficulties very costly to correct.

This upward resultant of the hydrostatic pressure is important in  
s e.

The buoyancy forces act on the bit, but are not distributed, as some people think, equally along the axis of the drilling-string and therefore cause the Basgan Effect which is the compressed zone and neutral zone in the drilling-string. By rotation at a speed of 100 to 300 R.P.M. the centrifugal forces cause buckling in the compressed zone and from this spring the entire series of difficulties in the drilling technique.

Various authors have tried to prove that buckling is possibly caused only by the buoyancy in a static condition, but I have not accepted this viewpoint.

For the practical application of my invention the following simple formula was cited:

There should be taken 15% of the drilling-string weight immersed in a drilling fluid of a density between 1.1 and 1.3 or 20% of the drilling-string weight immersed in a drilling fluid of density between 1.5 and 1.7 .

The weight calculated in this way represents the weight of the liquid volume displaced by the drilling-string, which added to the weight placed on the bit should equal the total weight of the proportional drill-collars.

A special statement of Archimedes' Principle for the case  
Of bars vertically immersed in a fluid

Relying upon my investigations and proven findings, I

prefer the following special statement of Archimedes' Principle :

*« A solid bar or rod vertically immersed in a liquid is pushed upwards by a force equal to the buoyancy, the application point of the force being the lower surface of the solid. »*

In our specific application, the drilling string vertically immersed in the liquid which fills the hole, at a great depth of 2 to 5 miles, is pushed upwards by a force equal to the buoyancy, which force reaches values as high as 10 to 30 tons acting on the lower surface of the drill string.

This force applies compression within a certain portion of the lower zone of the drilling string, up to the neutral zone.

This neutral zone separates the portion under tension, which is suspended from the hook, from the compressed portion which is under the effect of the hydrostatic pressures acting in vertical and horizontal planes. Therefore we have a resultant which acts in a direction opposite to that of gravity, that is to say, opposite to the direction of bit advance.

This manner of treating the problem was new in 1934 and was different from the classic one, in which the drilling string immersed in a liquid had to be considered as being pushed up by the buoyancy and having as the application point the center of gravity of the displaced volume of liquid, or that of the drilling string. As a matter of fact in 1934, in drilling technique, the Archimedean pressure was completely neglected and the drilling string entered into calculations using the apparent weight of steel and drilling fluid.

From my formula the following new hydrostatic principles have been obtained, which have been applied to drilling technique :

- 1) The hydrostatic pressure buoyancy is exerted on the lower surface of the drilling string vertically immersed in a liquid; this force acts vertically upwards.
- 2) The lower part of the drilling string suspended vertically in the liquid is under compression due to the buoyancy of the entire drilling string, not only to the buoyancy of the drill-collar itself.
- 3) The lower part of the drilling string vertically immersed in liquid and partially exerting force upon the bottom is under compression, and the weight of this lower part in compression is equal to the buoyancy of the entire drilling string plus the bottom reaction.
- 4) The total length of the bar up to the neutral zone (of uniform cross-sectional area) which is under compression due to the buoyancy and bottom reaction, is equal to the sum of the lengths represented by the compression due to buoyancy and the bottom reaction.

5) There exists a neutral zone at a specific cross-section of the bar which is vertically immersed in liquid, which zone separates the compressed part from the part under tension. The location of this neutral zone in the bar varies as a function of the depth at which it is immersed and of the weight placed on bottom.

6) The hydrostatic pressure due to the displaced volume of a drilling string immersed vertically in the liquid plus the bottom reaction, develop compression stresses at the lower end of the bar. These stresses are superimposing and additive.

Before my researches and inventions in 1934, it was considered that a column immersed in a liquid less dense than the drill-pipe material does not have a portion under compression and consequently that there is no neutral zone, as long as the drilling string does not touch the bottom.

Also, it was not believed that the hydrostatic pressure would have an application point at the lower end of the bar immersed in the liquid.

The ability to calculate the various weights involved is indisputably advantageous in drilling technique.

In 1934 specialists in drilling technique considered my recommendations as revolutionary.

My principle should be followed from spudding-in, starting with one drill-collar and gradually adding drill-collars as both the well depth and the drilling-string weight are increased, maintaining the ratio established by my formula.

The intermediate drill-collar weights, even those which are calculated only as a function of the drill-collar displacement, are also taking advantage of my contribution.

Depending on the depth and drilling pressure, one can reach a total proportional drill-collar length of 300 to 900 feet.

### The Application of Proportional Drill-collars

#### In Drilling Technique Throughout the World

During the years 1933 and 1934, in drilling technique, both inside and outside my country, drilling was performed with drill-collars having a



length of 18 ft. And a weight of 1.4 t. and for experimental purpose there were used 3 such drill-collars amounting to up to 5 t. in weight.

After the appearance of my patents in 1934 in Romania, and in the U.S.A. during the year 1937, and after presenting the theory to the World Petroleum Congresses (in London in 1933 and in Paris 1937), the total weight of drill-collars used in the industry increased appreciably.

My work dealing with this subject was immediately translated and published in the U.S.S.R., U.S.A., England, Austria, Germany, France, etc.

In all these countries, the use of increasing drill-collar weights and its application to problems regarding the technique of vertical, rapid and economical drilling, began immediately.

My invention was successfully tested in the oil fields of the Petrolifera Romina and Redeventa Companies and others, and the results were published in « Analele Minelor » of Romania, No. 7/1938.

#### U.S.S.R.

In the U.S.S.R. my researches have attracted the attention of specialists. In 1935 there appeared under my name - in Baku And Moscow - the work « The Scientific Basis of Modern Drilling methods », with a foreword by C. Siscenco. The famous Profs. Evseenco and Vozdjjjensky recognized the importance of the effect of hydrostatic pressure on the compressed drilling string, the neutral zone, and the role of drill-collars.

Prof. Evseenco confirmed this in chap. % of his book « Drilling Technique Development During the Third Five-Year Plan (1938-1942) - The introduction of drill-collars at the lower part of the drilling string ».

Prof. Ghevinian of the U.S.S.R., who attended the meeting of specialiste in Ploesti on November 1, 1939, spoke about the application in Baku of Basgan's drilling methods, about drilling with proportional drill-collars and also about rotary-percussion drilling. V.N. Kasianov published in « Nefteanoe Hzeistvo Review » No. 38 (1960) No. 3 (March) page 51-54, a very interesting article entitled « With regard to the calculation of sucker rod strings for pumping units », translated into Roumanian - « IDT - Petroleum Technique, No. 3/1960 », which took into account the influence of the Archimedean force, which is the resultant of the pressure of hydrostatic force on the sucjer rods immersed in liquid, exactly according to Basgan's recommendations.

#### U.S.A.

In the U.S.A., after I obtained the patent and after the document which I presented before the World Petroleum Congresses in London and Paris in 1937, the drill-collars used in oil fields increased immediately in length and weight, reaching 300-900 ft. and 10-30 tons, while this technical and scientific problem was widely debated in the meetings of specialists only after 1945.

In order to settle for good and all the controversies connected with this problem, I prefer to refer to the opinions of the leading technical and scientific authorities, expressed during the discussions at the A.P.I. meeting in 1949 and published in the technical literature.

I will quote from the interesting paper of Murray f. Hawkins and Norman Lamont of Louisiana University, Baton Rouge, La, presented at the API meeting in Galveston Texas in March 1949 and published in « Drilling and Production Practice », April 1949, vol. 10, No. 6

This paper states : « Equations for the axial strains and stresses in drill stems are presented. These indicate a neutral plane above which the drill stem is in tension, and below which compression exists because of the buoyant action of the drilling fluid. Experiments are described which establish the validity of the stress and strain equations. The work of G.H. Hendleman is presented to show the effect of buoyancy on the drill stem ».

The conclusions of Murray and Lamont's paper are quoted below :

#### « CONCLUSION »

From the theoretical and experimental work which has been done and in the light of Handleman's work, it is concluded that, in a string of drill-pipe suspended in drilling fluid, unless weighted properly with drill-collars, there will exist a neutral plane above which the pipe is in tension and below which the pipe is in compression. This compression is effective and will contribute to failure (more frequently fatigue failure nowadays) in the same way as excessive weight carried on the bit. It should be corrected by using sufficient drill collars to take care of the compressive stress which results from the hydrostatic buoyant force and from the weight carried on the bit. This is in agreement with Grant and Texter, who report that fatigue breaks are the most common type of drill-pipe trouble today; that fatigue failures occur predominantly in the lower part of the drill stem and that fatigue breaks may be reduced significantly by the use of adequate drill-collar weight » - So concluded the paper of Murray and Lamont.

In addition to the above, 15 years after my publications, my patent, and my public presentations, many other very well known professionals, researchers and American scientists have declared

themselves in support of what was actually my thesis, during discussions at the Galveston meeting.

The famous technician H.G. Texter said at that meeting:

« We agree with author's conclusion that within a drilling string, suspended into a liquid, there is a neutral zone, under which compression takes place due to the hydrostatic forces exerted by the drilling fluid ».

« The author is right when he ascertains that the deeper is the well, the more drill-collars are needed to be added to the drill-string in order to maintain the neutral zone the nearest possible from the superior part of the drill-collars ».

On the same occasion, the well known and famous researcher John L. Holmquist said :

« In this article the author is dealing with two conclusions at which he arrived with regard to the effect of different forces to which the drill-pipes are submitted during working; one refers to the existence and establishing of the neutral zone position the second refers to the axial compression produced and whether it has any deflecting or bending effect in this drilling string portion. »

I will mention the interesting work of Arthur Lubinski « Buckling of Rotary Drilling Strings », published in « World Oil » 1951 (4-7) in which the importance of hydrostatic pressure is confirmed and also the article written by D.M. Best (of Gulf Tool Company - Houston) in « World Oil » - March 1957 (XXVI).

D.M. Best takes into account the floating effect and weight of the liquid displaced by the drilling string, for the computation of drill-collar length, thus confirming exactly, by the calculation and field practice presented both scientifically and practically, the Basgan invention.

Best said that buoyancy alone would buckle a pipe and I said that the buckle is caused by centrifugal forces by rotation, and especially by the compressed zone.

Prof. Carl Garrlin of Texas University introduced in his course published in 1960 in U.S.A. the effects of the Archimedian force; and U.I. Okon presented in 1964 at the Petroleum Section of Oklahoma University a paper under the title: « Effects of the floating force on the drilling string », under the sponsorship of Prog. Moore had published a similar article.

In Okon's bibliography is shown a series of articles by American authors, which recognize the importance of the hydrostatic pressure in drilling technique and confirm the utilisation of proportional drill-collars for the realization of vertical holes and the effect of increase of the drilling speed on efficiency.

In 1959 in England, George Constantinescu held a conference about Basgan inventions, published in the Transactions of the Society of Engineers, London.

In France in 1946, there appeared the well documented technical scientific work of the engineer J.P. Bernhard commenting upon my paper presented to the World Petroleum Congress in Paris 1937.

I ought not to close this exposition without mentioning that my original technical scientific researches were presented at the time of my work for a doctor's degree. The paper was entitled « Die Arbeitweise und Form des Rotary Meißels » at the Superior Mining Institute in Leoben, Austria, and published by the Hans Urban publishing house in Vienna (1934).

Prof. Renato Calapso of Messina University, Italy, President of the first Archimedean World Congress, which took place in 1961, said in his preface to my book on this subject, that I have added an increased modern prestige to the great scientist of ancient Syracuse.

### SONIC DRILLING

By making numerous experiments, I checked and reached the belief that the bit, under certain conditions, can work by percussion simultaneously with the rotation, increasing the efficiency of the rotary drilling.

The tests performed in many oil fields, with rocks of various hardnesses and especially in the very hard rocks from Moinesti, Romania, have allowed me to establish the conditions under which there can be created a permanent field of vibrations by means of mud pumps. Also I established for the operating process of drilling, the weight that can be put on the bit at the bottom of the borehole, in order to obtain a new rotary drilling and simultaneous percussive method, which features important advantages regarding the drilling speed and the verticality and quality of the drilled hole.

By means of the simultaneous rotary-percussive drilling method, I succeeded, before 1934, for the first time in the world, in transmitting the sonic energy created at the surface, through the drilling string, to the bit, which causes the bit to vibrate up and down, with a definite frequency, following the direction of the gravity and thereby drilling vertical holes.

In this way there was created the Basgan simultaneous rotary-percussive drilling method, or « sonic drilling ».

In the patent covering my invention and in the subsequently published work as well, there is shown the installation and the process, by means of which there can be obtained a frequency within the infrasonics range, with percussions down to a few centimeters.

My drill-collars are playing an essential role in sonic drilling.

It resulted from my calculations that when the kinetic and the potential energies of the sonic current from drilling string mass are equal, the maximum mechanical work is attained. This takes place when the current pressure amplitude and the current amplitude are in phase.

The essential condition for transmitting this sonic current is for the drilling string to be continuously in tension. This means that the neutral zone which separates the compressed zone from the tensioned zone must be positioned within the drill-collars mass, and the weight on the bit must be adjusted in relation to the sonic energy, so as to allow the bit to vibrate up and down, in order to produce a percussive stroke.

Thus there will be insured the tension required for the propagation of the sonic current and for avoiding the so-called « tension-breaking » phenomenon in the drilling string, called cavitation.

Using these conditions there was developed the second drilling method using proportionate drill-collars, which increases the efficiency of rotary drilling and of sonic drilling too, producing, at the same time, vertical boreholes. I have obtained invention patents in Romania (Nr. 22789 of 1934) and U.S.A. invention patent (No 2103.137 of 1937).

The practical results obtained in oil fields were subsequently confirmed by mathematical calculations, and for this purpose, I made use of the mathematical formulas from the « Theory of Sonics » by George Constantinescu.

By means of this theory I calculated the propagation velocity of the waves started in the liquid circuit and in the steel mass of the drill pipes, which velocity was confirmed also by means of Allievi's formulas. The propagation velocity of the sonic waves through the mass of the drilling string is **5000m/s**, and the drilling mud flow is of **1330m/s**.

Also by using the formulas from the « Theory of Sonics » I have calculated the mechanical work performed by the sonic current transmitted through the drilling string from the surface to the bit, when the latter is working on the bottom of the hole, vibrating up and down.

The sonic calculations confirmed the practical results obtained in oil fields and the significance of the mechanical work obtained with the new sonic drilling method.

These researches and achievements were published in 1934 in Vienna, with a foreword written by Eng. G. Constantinescu.

#### The Simultaneous Rotary-percussive Drilling Method Sonic Drilling

This drilling method combined in a new single system the advantages of rotary drilling method, (characterized by its rapid advancement), with those of the percussive method, (characterized by the verticality of the drilled hole), thus accomplishing increased drilling speed, and good quality and perfectly vertical bore hole.

The percussion breaks the rock and the rotation cleans the hole.

The drilling conditions which determine the efficiency of drilling are: the weight on the bit, the rotary speed, the volume and speed of the mud flow in the annular space, and the number of pump strokes per minute, to which I have added new factors of particular importance, like : reduction of the length of the compressed lower zone of the drilling string, which has the effect of the elimination of the compression of the drill pipe and the creation of the percussive action of the bit, simultaneously with its rotation.

The sonic drilling technique can be obtained by creating the vibrations in various ways : (1) at the surface by hydraulic or mechanical and sonic means, allowing the transmission of the waves along the drilling string down to the bottom, (2) underground, creating the vibrations as much as possible directly only to the bit, using the principle of the pneumatic or hydraulic hammer with percussive motion, based on resonance, (3) magnetostriction, (4) piezoelectricity, (5) other methods.

The oscillatory movement of both ends of the drilling string, (at the surface as well as down at the bit), is accomplished by means of one or more sonic generators with pistons, which supplies liquid to the drilling fluid system, and causes a pressure variation inside the drilling string, creating a periodic force with the required frequency, which is adjustable.

These pressure variations cause variable tension stresses in the mass of the drill pipe, creating and maintaining a continuous sonic current in the drilling string. This is affected as well by (1) the rhythm of periodic force caused by pressure variations, (2) the inner diameter of the drill-string, and (3) the manner in which the drill pipe is working.

The total mechanical work performed by the power transmitted through a sonic flow at the bit helps more than the rotation in breaking and chipping the rock, since the bit falls continuously perpendicularly, and the rotation and the mud flow, scrape and clean the bore hole.

By means of simultaneous rotary-percussive drilling there was achieved, sonically, the transmission of a supplementary wave of energy, with a velocity of 5000 m/sec., which allows the bit to execute percussive blows which break the rock ; Under these conditions, the rotation drills a perfect vertical hole, under economically superior conditions.

In this way there was accomplished drilling with variable weight on the bit ; the working time of the bit on the bottom was extended and more vertical and more economical bore holes were drilled, which in the future will attain the great depths required by modern engineering.

At the seventh World Petroleum Congress held in Mexico between April 2 and 8<sup>th</sup>, 1967, in my paper entitled : « The limitation of the Archimedean pressure effect and sonic energy, as essential conditions for the future of deep well drilling »,

I have called attention to the possibilities for modern engineering to drill beyond actual depths of 21,000-24,000 feet, indicating simultaneous rotary-percussive drilling (sonic drilling) as the future way of achieving such results.

In order to reach such great depths it is essential to limit the effect of the Archimedean pressure. On the other hand, the transmission of sonic energy of power at the bit, thus offering a technological process having great superiority over the rotary system.

Note that a drilling column of aluminium and titanium alloy is almost twice as light as a corresponding one of steel of the produce is exactly the same. Hence the fact that the neutral zone is situated much higher in the drilling column than in the case of a steel column ; this compels us to use steel drill-collars proportional to the depth, even for aluminum drill pipes.

As in the case of steel drill pipes, these drill-collars must have the same weight as that of the displaced liquid plus the drilling-pressure on the bit. It will then succeed in lowering the neutral zone and obtaining a « plumb-bob » condition, avoiding there by deviation of the hole and bottom mishaps with all their annoying consequence as shown in detail in the quoted references.

As previously mentioned, the rotary-percussive system executed in accordance with the above shown procedure, assures a supplementary energy, which permits us to produce, simultantaneously with the rotation, percussion strokes, which in the rock breaking process is superior to simple rotary drilling. This was proved experimentally both in the U.S.S.R. and in the U.S.A. and emphasized by engineer George Constantinescu (originator of the sonic science), at the conference held in London in 1959 on the subject « Sonics ».

Thus a sonic load of on  $\text{kgf/mm}^2$ , which would be the maximum amplitude of pressure of the sonic current, represents an insignificant stress, from the point of view of ultimate strenght of a material like steel of  $126 \text{ kgf/mm}^2$  elastic limit, whereas the effect on the bit represents a supplementary mechanical work of some thousands of  $\text{kg/cm/second}$ , which contributes directly to the dislocation of the rock at the bottom of the hole.

By this drilling method the life of a drilling bit in the hole is considerably increased, thus realizing a very important economy in interruptions for changing bits which is an enormous factor in drilling yield, especially when it conerns depths of the order of  $6 \frac{1}{4}$  miles.

These methods can be applied without the use of any tool or complicated apparatus at the bottom, such as turbines or other devices, none of which proved successful beyond certain depths. The sonic power is generated at the surface and is simply transmitted to the bit by the drilling column at the speed which we have already mentioned, which is  $5,000\text{m/s}$ .

In conclusion, we can state that the rotary-percussive method combined with drill-collars proportionate to the variable but limited pressure, constitutes the technique of the future for attaining great depth drilling.



It does so, because of the simplicity of its equipment, its flexibility, and the applicability of this technological process to hard rock sites, inclined formations, etc.

The perpendicularity of drilling, initially and during the drilling work is one of the essential conditions in deep drilling, a condition which is amply fulfilled by these methods.

Vertical drilling is characterized by evenness, lack of doglegs, lack of key holes and the elimination of shape changes when the hole tends to deviate.

By using, from the very start of drilling, the proportionate oversized drill-collar drilling method, combined with sonic drilling, adjusted to the conditions of the ground, we can ensure a perfectly vertical bore hole.

The limitation of the Archimedean pressure effect and the transmission of the power generated, at the surface, by sonic means through the drilling string, without complicated under-ground outfits, as previously shown, constitutes the technique of the future for deep well drilling ».

According to my extensive experience in oil drilling and the above presented principles and procedures, I have obtained a new U.S. Patent No. 3,507,341 for « Process and System for Rotary Drilling with Drilling Fluid- Imposed Sonic Vibrations ». Patent were also issued in Romania, France, Portugal and other countries.

My presence in the United States, the country which is the spearhead of technological progress in the world and which has put the first man on the moon, has as its goal to point out the Romanian contributions and prior discoveries and innovations in science and drilling technology, as well as to put into use my patent, so as to set at the United States' and the world's disposal the wealth and the energy locked in the Earth's crust, to depths up to 15 km (45,000 feet).

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