166-308 SR
09-12-72 XR 3,690,380

United States Patent

Grable

[15] 3,690,380
[45] Sept. 12, 1972

[54] **WELL APPARATUS AND METHOD OF PLACING APERTURED INSERTS IN WELL PIPE**

[72] Inventor: **Donovan B. Grable,** 2515 San Francisco Ave., Long Beach, Calif. 90806

[22] Filed: **June 22, 1970**

[21] Appl. No.: **47,957**

[52] **U.S. Cl.** **166/298,** 166/55.1, 166/229, 166/308, 166/55.3

[51] **Int. Cl.**.....**E21b 43/11,** E21b 29/00

[58] **Field of Search**.....166/229, 227, 278, 297, 298, 166/314, 315, 308, 242, 157, 74, 100, 55.1; 175/3.5, 4.57, 77

[56] **References Cited**

UNITED STATES PATENTS

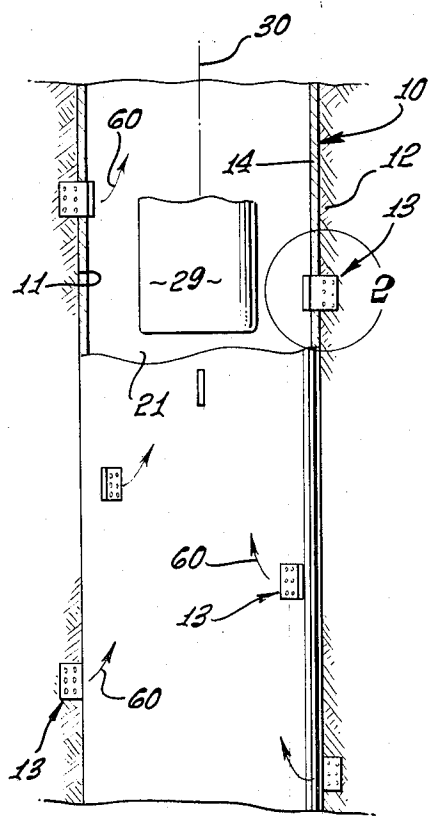
3,236,304	2/1966	Sarapuu	166/55.1 X
3,419,089	12/1968	Venghiattis	175/4.57
3,301,337	1/1967	Vaughn et al	175/77 X
2,544,601	3/1951	Kinley	166/229 X
1,629,018	5/1927	Coberly	166/229
2,303,727	12/1942	Douglas	166/100 X
3,361,204	1/1968	Howard et al.	166/55.1 X
3,430,711	3/1969	Taggart	166/100 X
3,338,307	8/1967	Redwine	166/100
2,546,669	3/1951	Kirby	175/77

Primary Examiner—Stephen J. Novosad
Attorney—White, Haefliger & Bachand

[57] **ABSTRACT**

A projection containing through porting is displaced endwise and relatively through a well casing wall to cause the projection to penetrate the surrounding formation. The displacement is completed when the through porting bridges the casing wall, thereby to channel the production flow through such porting.

16 Claims, 14 Drawing Figures



PATENTED SEP 12 1972

3,690,380

SHEET 1 OF 2

FIG. 1.

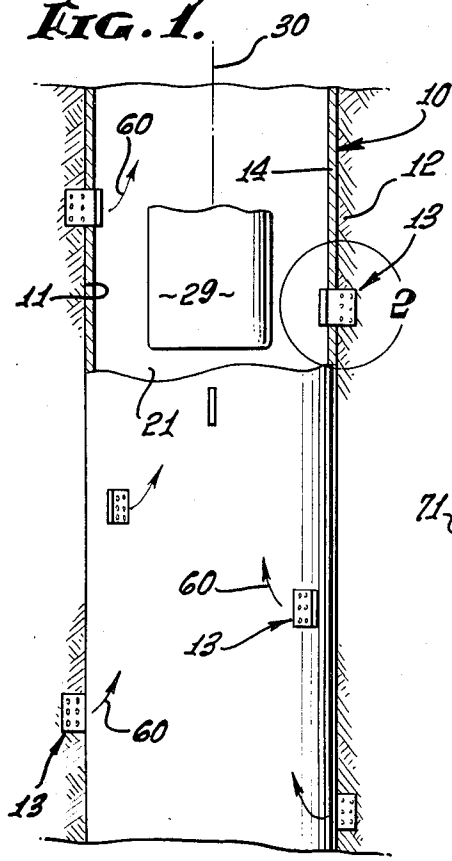


FIG. 13.

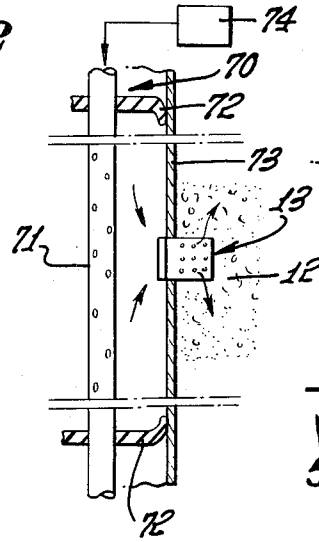


FIG. 3.

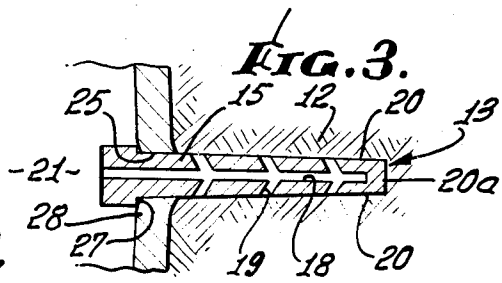


FIG. 4.

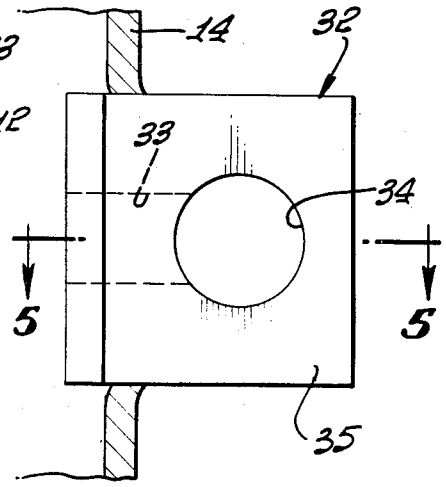


FIG. 14.

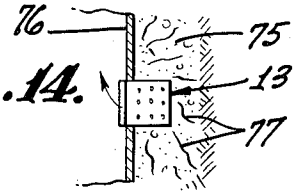


FIG. 5.

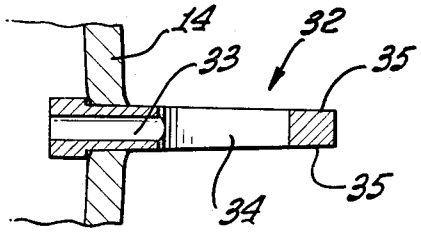
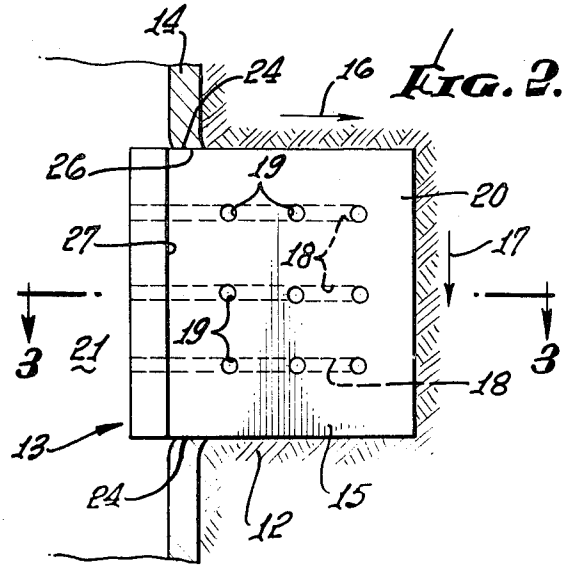


FIG. 2.



INVENTOR.
DONOVAN B. GRABLE
By
White, Haefliger & Bachand
ATTORNEYS.

FIG. 6.

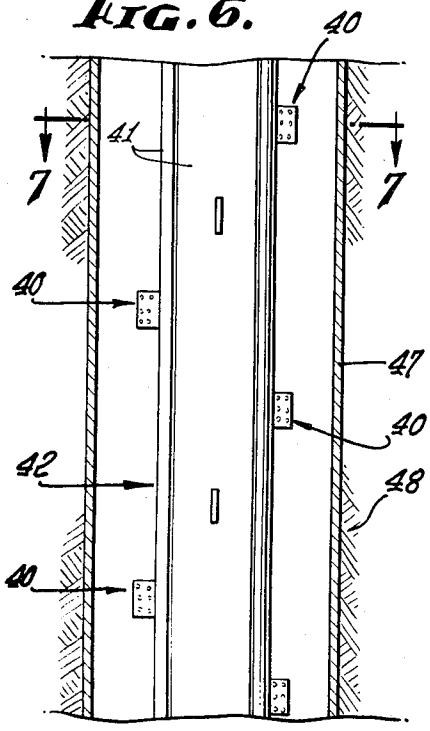


FIG. 12.

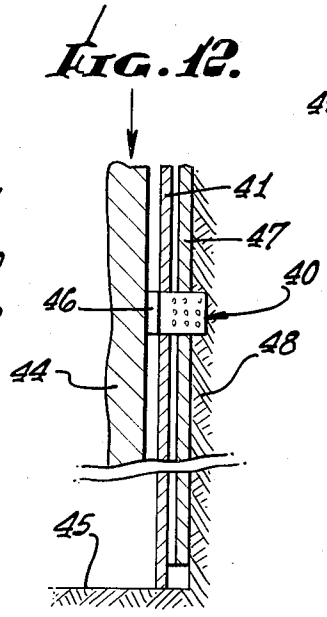


FIG. 7.

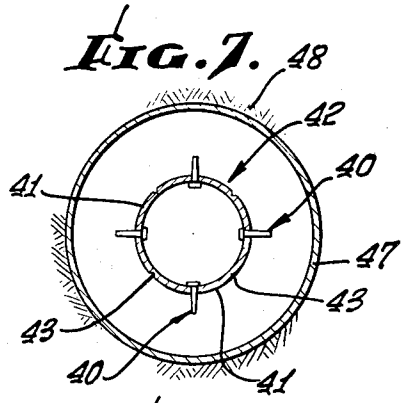


FIG. 8.

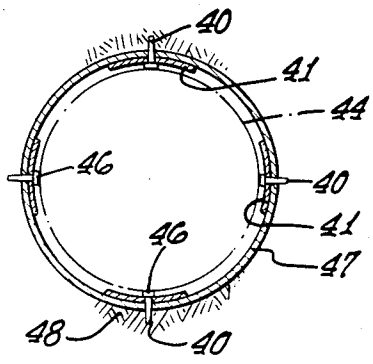


FIG. 9.

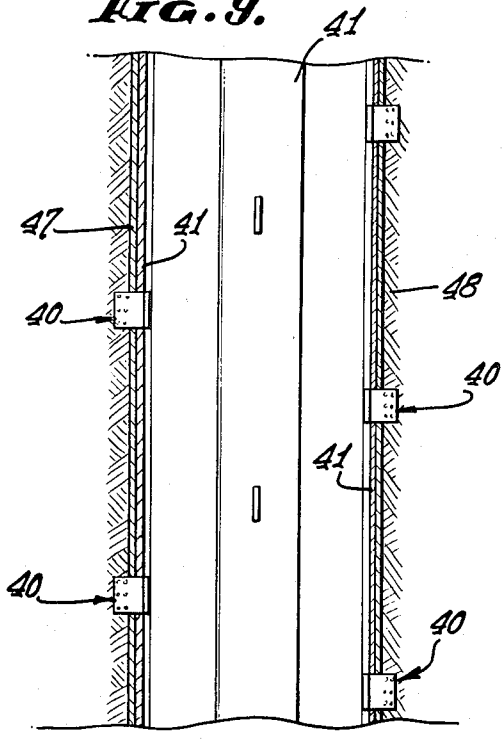


FIG. 10.

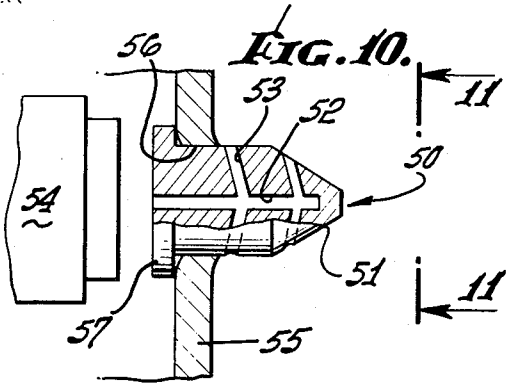
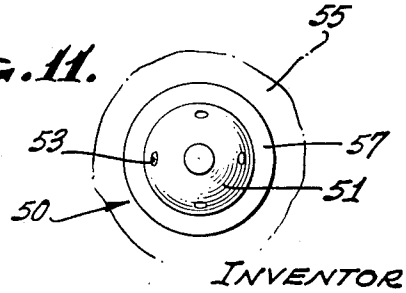


FIG. 11.



INVENTOR

DONOVAN B. GRABLE

By

White, Haefliger & Packard

ATTORNEYS.

WELL APPARATUS AND METHOD OF PLACING APERTURED INSERTS IN WELL PIPE

BACKGROUND OF THE INVENTION

This invention relates generally to oil and gas well production. More specifically, it concerns increasing the flow of production fluid and preventing erosion and destruction of casing or liners in wells.

In the past, reliance has been placed upon perforations in well casings to pass or drain the production fluid from the surrounding formation into the casing for subsequent flow to the surface. Such perforations may be pre-formed in the casing prior to installation in the well, or they may be formed by perforation techniques carried out in the well, as for example gun perforation. In either case, problems of abrasive erosion of the casing remain, sand particles in the oil flow tending to cut the casing metal surrounding the perforations and eventually leading to its destruction and diminished functioning of the well. Also, small width perforations of a size to prevent large particle entrance into the casing undesirably restrict the in-flow of production fluid, and frequently become plugged, leading to loss of production.

SUMMARY OF THE INVENTION

It is a major object of the invention to provide apparatus and method characterized as overcoming the above described problems, as well as offering unusual advantages in the operation of oil and gas wells.

Basically, the method of the invention concerns increasing effective flow-passing communication between the exterior and interior of casing set in a well through use of a projection of strainer having a nose (typically hardened) at one end, and through porting extending lengthwise of the projection. The method involves displacing the projection endwise and relatively through the casing wall to cause the nose to penetrate the surrounding formation; and, completing such displacement when the through porting bridges the casing wall, thereby to channel the production flow through such porting. As will appear, cutting and wear action of the sand particles upon the casing or liner are substantially reduced since the projection itself will be subjected to wear rather than the casing exterior, and the projection may be hardened to resist such wear. Also, production in-flow, or drainage from the formation, will be increased due to the penetration of the projection and porting therein into the surrounding formation for increasing the flow collection area or zone. Further, should the projections become clogged, new ones may easily be inserted through the wall of the casing set in the well.

Additional steps of the inventive method include displacing the projection into the formation until a flange or shoulder on the projection is brought into load transmitting relation with the casing inner wall; carrying multiple projections on spreadable sections of a pipe within the casing and urging the sections toward the casing wall as by means of a swaging tool; displacing multiple projections through the casing wall and into a surrounding cement formation to fracture the latter and open up fracture paths for oil and gas flow into the casing; flowing liquid from within the casing to the exterior via the porting in the projections, as during washing for example; and producing the well via the porting in the multiple projections extending into the formation.

In its apparatus aspect, the invention concerns the provision, in combination with well casing, of a projection as defined; the incorporation on the projection of a flange or shoulder facing the inner side of the casing wall for limiting outward displacement of the projection through that wall; the use on the casing of multiple spaced projections as defined, which may be of various shapes and consist of sufficiently hard material to penetrate the casing and also to resist particulate abrasion; the supporting of the projections on pipe sections within the casing and subject to spreading as by a swedging tool to urge the projections through the casing and into the formation; and the use of various tools within the casing and located to urge the projections outwardly, as will be described.

These and other objects and advantages of the invention, as well as the details of illustrative embodiments, will be more fully understood from the following detailed description of the drawings, in which:

DRAWING DESCRIPTION

FIG. **1** is a side elevation showing multiple projections extending through casing and into a formation;

FIG. **2** is an enlarged side elevation showing one of the FIG. **1** projections;

FIG. **3** is a horizontal section taken on line **3—3** of FIG. **2**;

FIG. **4** is a view like FIG. **2** showing a modified projection;

FIG. **5** is a section taken on line **5—5** of FIG. **4**;

FIG. **6** is a view like FIG. **1** showing auxiliary support of the projection, prior to their penetration of the casing;

FIG. **7** is a section taken on lines **7—7** of FIG. **6**;

FIG. **8** is a view like FIG. **7** but showing urging of the projections through the casing and into the surrounding formation;

FIG. **9** is a vertical elevation like FIG. **6**, but showing the projections after their installation;

FIG. **10** is a view like FIG. **3**, but showing a modified projection;

FIG. **11** is an elevation taken on line **11—11** of FIG. **10**;

FIG. **12** is a fragmentary elevation showing the use of a swedge to urge a projection through the casing; and

FIG. **13** is a fragmentary elevation illustrating penetration of a projection into well cement, to fracture same; and

FIG. **14** is a fragmentary elevation illustrating use of a washing tool in conjunction with a projection.

DETAILED DESCRIPTION

Referring first to FIGS. **1 – 3**, a well casing **10** lines a well **11** drilled into an oil or gas (or other fluid) producing formation **12**. Multiple projections **13** are carried by the casing wall **14** to extend outwardly therefrom, penetrating the formation, the projections being spaced apart axially and circumferentially of the casing as desired. The projections contain through porting to intercommunicate the casing exterior and interior, thereby to pass well fluid therebetween via the projection.

One particularly advantageous projection **13** shown in FIGS. **2** and **3** includes a narrow width body **15** which is elongated and tapered lengthwise in the direction of arrow **16**, and also elongated laterally in the direction of arrow **17**. It contains elongated central ports **18** extending lengthwise and spaced laterally, and short branch ports **19** extending from the main port to opposite sides **20** of the body to communicate the formation **12** at those sides with the central ports and the casing interior **21**. Accordingly, well fluid may drain or flow from the formation through the casing wall and to the casing interior for upward flow at **60** in the latter, without subjecting the wall to particle cutting at the point of passage through that wall; instead, the projection itself is subjected to the abrading action of sand particles, but the greater hardness of the projection body (heat treated steel or alloy) resists such abrasion. Also, the multiple projections, by virtue of their greater surface and port exposure to the surrounding formation as compared with the surface of the casing, contribute to increased production flow into the casing. Should the projections become clogged, others may be easily installed; also, should the projection eventually wear away, the in-flow may continue through the perforation **25** in the casing.

Note that branch ports **19** slant from the main port **18** rearwardly toward the casing, so as not to become clogged when the projection bodies are displaced outwardly into the formation **12**.

The nose **20***a* of each steel (or alloy steel) projection is of sufficiently greater hardness than that of the steel casing that the projection may be forcibly pushed through the casing wall and into the formation, the opposite sides **20** and ends **24** of the projection tightly and frictionally engaging the casing perforation edges **25** and **26**, as shown, to hold the projections in place. A flange or shoulder **27** on the projection is brought into load transmitting engagement, or near engagement with the casing inner wall **28**, upon installation of the projection, whereby that shoulder limits outward displacement of the projection into the formation. A tool to accomplish such installation, as by exerting force in the direction of arrow **16**, is indicated generally at **29** in the casing in FIG. **1**, the casing axis appearing at **30**. Such a tool may for example comprise a fluid pressure responsive actuator, or a swedge, or a gun operable to explosively shoot the projections through the casing wall. Thus, the projections might by lowered on the tool, suspended by wire line, and then displaced through the casing as described.

FIGS. **4** and **5** illustrate a modified projection **32** having a main port **33** terminating at a passage **34** extending through the projection between opposite sides **35** thereof. That passage serves as a relatively large and open collection zone for well fluid to facilitate its drainage through port **33** to the casing interior. Note that the main port **33** is elongated lengthwise of the casing, as appears in FIG. **4**.

FIGS. **6** and **7** show the initial support of projections **40** on sections **41** of a pipe **42** lowered within the casing. That pipe is longitudinally scored at locations **43**, whereby the pipe sections **41** are separable in response to expansive force transmission to the pipe, as by means of a tapered swedge indicated at **44** in FIGS. **8** and **12**. After the inner pipe **42** is landed in the hole, as at the bottom **45**, the swedge is lowered to progressively engage the heads or flanges **46** of the projections, with force transmission sufficient to separate the pipe sections **41** and drive them outwardly, the projections then being driven through the casing **47** as shown and into the formation **48**.

FIGS. **10** and **11** show another modified projection **50** which is circular in cross section. The hardened nose **51** is frusto-conical, and main and branch ports **52** and **53** communicate the casing exterior and interior through the projection body. A gun **54** is operable to fire the projection through the casing wall **55**, penetrating same at **56**. A head or flange **57** on the projection limits its penetration into the formation by engagement with the casing inner wall.

FIG. **13** illustrates the step of flowing wash liquid from within the casing to the formation **12** via the projection **13** of the type seen in FIGS. **1 – 3**. A straddle tool **70** lowered in the casing comprises a wash pipe **71** and cups **72** carried on the pipe and sealing against the casing **73** above and below the projection **13**. Pressurized wash liquid flows from the pipe to the casing interior between the cups and then via the projection to the formation. If desired, the pressure may be such as to aid in fracturing the formation to increase the flow of production fluid to the casing via the projection. A source of pressurized liquid is indicated at **74**.

FIG. **14** indicates a projection **13** which is wedge-shaped as seen in FIG. **3**. It has been driven through the casing **76** and into a body of cement **75** installed around the casing. The penetration of the projection into the cement fractures the latter, as indicated by cracks **77**, to aid in increasing the flow of well fluid to the casing interior via the porting in the projection body.

I Claim:

1. In combination with well casing,

a. a projection carried by the casing wall and extending outwardly therefrom,

b. the projection containing through porting to intercommunicate the casing exterior and interior, thereby to pass well fluid therebetween via the projection,

c. the projection being elongated in said outward direction and also in the direction of the casing length, in relation to the projection width, and

d. said porting including elongated main ports extending in said outward direction and spaced apart in said casing length direction, and branch ports communicating the mainports with side surface portions of the projection.

2. The combination of claim **1** wherein the projection has an outwardly facing terminal that is hardened to an extent facilitating forcible penetration thereof through the casing wall.

3. The combination of claim **1** wherein the projection penetrates through said wall, and including a shoulder on the projection and facing toward the inner side of the casing wall for limiting outward displacement of the projection through said wall.

4. The combination of claim **3** including multiple projections as defined and penetrating the casing wall at spaced locations.

5. The combination of claim **3** including a tool in the casing transmitting force urging the projection in a direction away from a casing defined axis.

6. The combination of claim 5 wherein said tool comprises a gun.

7. The combination of claim 5 wherein said tool comprises a hydraulic actuator.

8. The combination of claim 5 wherein said tool comprises a swedge.

9. The combination of claim 1 including hardened cement at the outer side of the casing and into which the projection penetrates, the cement forming cracks to pass well fluid to said projection and porting therein.

10. The combination of claim 1 including the well formation into which the projection penetrates at the casing exterior, the formation being porous to pass well fluid to the projection and porting therein.

11. The combination of claim 1 including a washing tool in the casing flowing liquid from the casing interior to said porting for subsequent flow therethrough to wash a formation into which the projection penetrates. In combination with well casing,

a. spread apart pipe sections at the inside of the casing and multiple projections carried by said sections, the projections penetrating outwardly through the casing at spaced locations, there being shoulders on the projections facing outwardly to limit outward displacement of the projections relative to said sections, and

b. the projections containing through porting to intercommunicate the casing interior and exterior to pass well fluid therebetween via the projections.

13. The method of facilitating communication between the exterior and interior of well casing in a well formation and utilizing a projection having a nose at one end thereof, a shoulder spaced from said nose, through porting extending lengthwise of the projection, and a pipe carried section within the casing supporting the projection proximate said shoulder, that includes:

a. displacing said projection relatively through the wall of the casing to cause said nose to penetrate said formation and to urge said section toward the casing inner wall, and

b. completing said displacing when said through porting bridges the casing wall.

14. The method of claim 13 wherein a cement formation extends exteriorly of the casing, and said displacement of the projection is carried out to effect projection penetration and fracturing of the cement formation thereby to facilitate well fluid flow via the fractures and projection to the casing interior.

15. The method of claim 13 including the step of flowing washing liquid from within the casing to the formation outside the casing via said porting in the projection and after completion of projection displacement as defined.

16. The method of claim 13 including the step of flowing well fluid from the formation to the casing interior via said porting in the projection and after completion of projection displacement as defined.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,690,380 Dated Sept. 12, 1972

Inventor(s) Donovan B. Grable

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 19; " In combination with well casing, " should read -- 12. In combination with well casing, --

Signed and sealed this 1st day of May 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.