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#4488-Reissue - APPARATUS FOR
DRAWING AND PULL-ROLLING UNDER
HIGH PRESSURE. B.I. Beresnev...

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HB No. 4488
Reissue

APPARATUS FOR DRAWING AND PULL ROLLING OF METALS UNDER HIGH HYDROSTATIC (LIQUID) PRESSURE

B. I. Beresnev, L. F. Vereshchagin, and Yu. N. Ryabinin

[Translated from TSVETNYE METALLY, vol. 31, 1958, #8, 61-63]

Synopsis.

Bridgman's work on drawing steel into wire under high hydrostatic pressures.

Work done in the Soviet Union on the extrusion of metals by high-pressure liquids.

Design of preliminary laboratory equipment for (a) drawing metals into wire (Fig. 1b) and (b) pull-rolling of metals (Fig. 1c), both under high hydraulic pressures.

Design details of new laboratory apparatus (Fig. 2) developed for cold drawing and rolling --currently of aluminum-- under pressures of about 10,000 kg/sq cm (63.5 tsi).

Principle of apparatus; its operation; steel compositions used for its most highly stressed parts.

Brutcher Translation

Problems of studying the laws of plastic deformation under high hydrostatic pressures have occupied the attention of foreign and Soviet investigators [1-3]. They established the effect of high hydrostatic pressure upon the strength and plasticity of materials subjected to deformation under these conditions. In the work of P. Bridgman [1], of practical interest are tensile tests of steel specimens prestrained in tension under high hydraulic pressures. He was the first to show that preliminary deformation of a metal in a highly pressurized liquid is reflected in its subsequent mechanical properties.

With a view toward practical improvement of metal properties, he was also the first to propose the method of drawing metal into wire by conducting the process in a hydrostatic pressure zone (Fig. 1). It is known that the method of drawing metal into wire according to arrangement (a) is widely used in modern technology. The blank 1, placed in the die 2, suffers plastic deformation upon application of the force K, and changes its size from initial diameter D to a final diameter d. As a result of the strain hardening involved, the strength of the metal increases, but its ductility deteriorates simultaneously until a stage is reached when plastic deformation becomes impossible and failure results. To realize substantial deformations it is necessary to give periodic (process) anneals which impart to the metal an equilibrium structure; however, along with this, the previously attained strength increase is lost. P. Bridgman showed that when such process is conducted in a liquid under a pressure of 12,000 kg/sq.cm (173,000 lb/sq.in) for steel, it becomes possible to attain high reductions without

any process anneals, thus preserving the improved properties of the steel. It should be pointed out that these tests were only preliminary in character, and that no circumstantial study of the mechanical properties of the metal was carried out.

First by P. Bridgman, and later by us in the Laboratory of Physics of Extremely High Pressures of the USSR Academy of Sciences, use was made of another method of converting metal into wire, involving its extrusion by high-pressure liquid [1, 4]. Mechanical tests on a number of nonferrous metals and alloys extruded by high-pressure liquid indicated an improvement of these properties by such a method of cold working. It was also shown that the retained ductility of aluminum extruded by a liquid depends upon the magnitude of the pressure.

It is known that the particular stressed state in accordance with which the deforming process is carried out is reflected in the residual change of the mechanical properties of metal [1, 2]. It is interesting to compare the mechanical properties of metals prestrained by different methods in the high hydrostatic pressure zone, in order to select the most effective deformation program. A unit was constructed for two methods of deformation of metals in the pressure zone: drawing and rolling with freely rotating (free-running) rollers.

Fig. 1-b shows a sketch of the arrangement of the unit for drawing in high-pressure liquid. The cylindrical blank 2 of diameter D, turned down at one end to diameter d, is fitted in die 3, and the assembly is then placed in the high-pressure vessel 1, which is divided into two non-communicating compartments.

The end of blank 2 (diameter d) is connected with the aid of the clamp 5 with the movable rod 6, whose upper and lower ends are located in different compartments of the high-pressure cylinder. If a pressure P_1 is created in the high-pressure cylinder, and a lower pressure P_2 in the lower compartment, then there will be obtained a pressure drop $P_1 - P_2$, as a result of which the movable rod 6, connected with blank 2 will be propelled from the upper into the lower compartment of the high-pressure cylinder; simultaneously, the blank will be deformed in the die 3 (from diameter D to diameter d) under pressure P_1.

Fig. 1-c shows a sketch of the arrangement for metal rolling with free-running rollers in pressurized liquid. In this case, the arrangement of the unit and the principle of action of the forces are analogous to the unit for drawing. The differences amount merely to replacement of the die 3 by the mount 4 with the two free-running rollers 7 inserted therein. The blank for rolling in this case has the form of a rectangular strip. As a result of the deformation that takes place, the thickness of the blank is reduced from H to h.

The above-described arrangements formed the basis for designing an installation (Fig. 2) to realize the processes of drawing and rolling metals with free-running rollers in liquid under 10,000 kg/sq.cm (142,200 psi or 63.5 tsi) pressure.

The cylindrical blank 12 was placed in die 11. One end of the blank was connected by means of a collet chuck 10 with the movable rod 9. Die 11 is immovably fixed in the parts 13 and 8, which are held together by a screw thread. A screw thread

also connects the intermediate part 8 with cap 6, containing the reverse valve 5, which is pressed downward by spring 7, and which has a through opening to accommodate the travel of rod 9. This entire arrangement is placed prior to the test in the inner channel of the high-pressure cylinder 2, which is fixed in the plates 1. The upper and lower parts of the inner channel of the high-pressure cylinder are closed by seal 14, which is designed on the basis of the principle of the uncompensated platform [5,6].

The high-pressure liquid is fed from a laboratory high-pressure pump (with a capacity of 3.8 liters = 1 gallon per hour against a 10,000 kg/sq.cm = 142,200 psi pressure in the feed line) through the inner bore of obturator (stopper) 3 into the inner channel of the high-pressure cylinder, thereby raising the reverse valve 5. The pressure of the liquid is indicated on a spring manometer installed on the hydraulic compressor. The installation is thus prepared for the actual test. As a portion of the liquid is drained through valve 16, the reverse valve 5 settles with its lower end, which holds the copper ring 4, upon an annular knife recess on the obturator 3. From this instant on, the inner channel of the high-pressure cylinder 2 is divided into two mutually non-communicating compartments. By continuing the drainage of the liquid through the valve 16, it is possible to create on the reverse valve a pressure drop (cf. Fig. 1-b) sufficient to permit the movable rod 9 to draw the blank 12 through the die 11.

The pressures in the upper part of the inner channel of the high-pressure cylinder are measured by a spring manometer installed on the tee 15; those in the lower part of the inner channel of the high-pressure cylinder are measured by a manometer on the hydraulic compressor [pump?].

During the process of deformation of the blank, the volume of the upper part of the high-pressure cylinder changes since the rod 9 moves into the lower compartment of the inner channel. To prevent a decrease in pressure in the upper compartment, provision was made for preliminary filling of the inner channel with gas (nitrogen) under 100 kg/sq.cm (1422 psi) pressure, which considerably improved the conditions for conducting the test.

The sequence of steps for the proposed set-up for the process of rolling metals with freely rotating rollers is analogous to that for drawing. However, in this case (cf. Fig. 2, Assembly B), die 11 is replaced by the mounting 19 with the freely rotating rollers 19 inserted therein, through which blank 17 is passed.

The most vital parts of the installation are made of alloy steels and suitably heat treated. The high-pressure cylinder 2 is made of 45KhNMFA (0.42-0.50% C, 0.17-0.37% Si, 0.50-0.80% Mn, 0.030% max. S, 0.035% max. P, 0.80-1.10% Cr, 1.30-1.80% Ni, 0.20-0.30% Mo, 0.10-0.20% V) steel with a Rockwell C hardness of 45-48; die 11, movable rod 9, reverse valve 5, and rollers 19 are machined from ShKh15 (0.95-1.10% C, 0.15-0.35% Si, 0.20-0.40% Mn, 0.020% max. S, 0.027% max. P, 1.30-1.65% Cr, 0.30% max. Ni, 0.25% max. Cu)

steel (with R_C = 60-62).

The above-described installation was used to carry out tests on the drawing and rolling of aluminum specimens to various reductions while under various pressures in the high-pressure chamber.

References

[1] P. Bridgman, "Investigations of Large Plastic Deformations and Rupture" (Russian Translation), INTERNATIONAL LITERATURE PRESS, Moscow, 1955.

[2] S. I. Ratner, "Strength and Plasticity of Metals" (in Russian), OBORONGIZ (Defense Press), 1949.

[3] Yu. N. Ryabinin, L. D. Livshits and L. F. Vereshchagin, "Plasticity of Brass under Super-High Pressures", ZHUR. TEKH. FIZ., vol. 27, #10, p. 2321, 1957.

[4] B. I. Beresnev, L. F. Vereshchagin and Yu. N. Ryabinin, "Rheological Behavior Characteristics of Liquid-Pressed Metals", IZVEST. AKAD. NAUK SSSR, OTDEL. TEKH. NAUK, 1957, #5.

[5] P. Bridgman, "Physics of High Pressures" (Russian Translation), ONTI (United Scientific-Tekhnical Press), 1935.

[6] D. S. Tsiklis, "Technique of Physico-Chemical Investigations under High Pressures" (in Russian), GOSKHIMIZDAT (State Chemical Press), 1951.

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B. I. Beresnev and Others,

Apparatus for Drawing and Pull Rolling of Metals Under High Hydrostatic (Liquid) Pressure.

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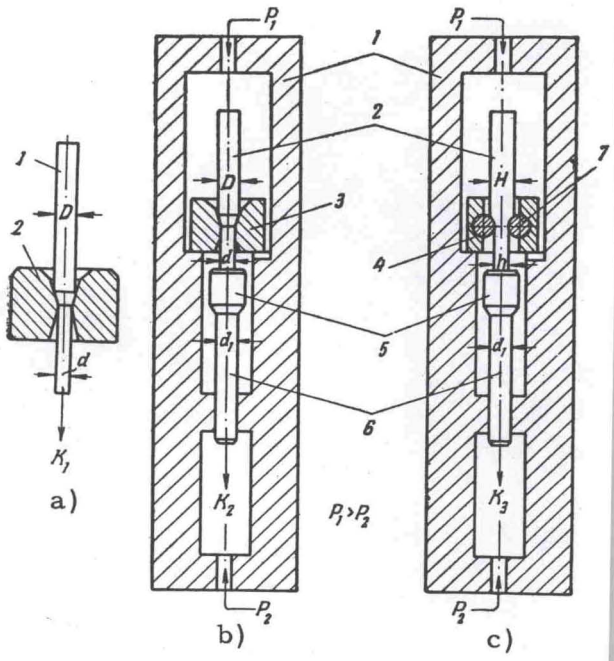


Fig. 1. Sketch illustrating the deformation of metals by (a) conventional drawing; (b) drawing in pressurized liquid; and (c) pull rolling.

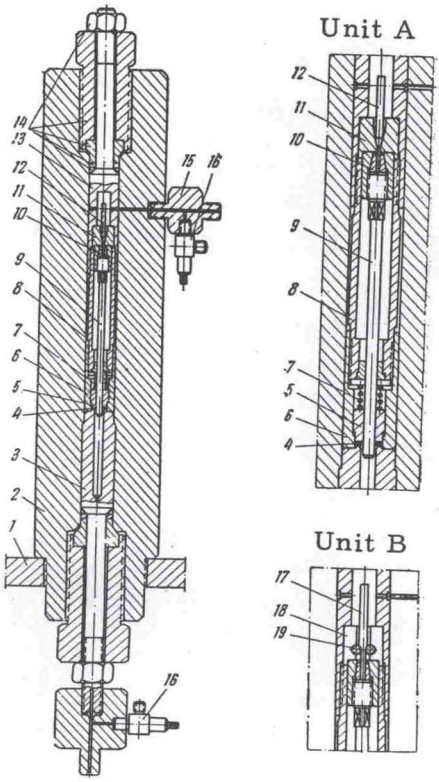


Fig. 2. Set-up for drawing and pull rolling of metals in pressurized liquid.

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Manufacture of Steel Wire- 7 (Reissued)

Order No.

5664 Developments in the Manufacture of High-Strength [Steel] Wire. C. Eisenhuth. STAHL UND EISEN, vol. 82, 1962, #14, pp. 945-52; 13 figs., 4500 words. [Review of progress in steel wire manufacture. Increases in coil weight and productivity; most important types of multiple-draft machines (Fig. 1); time requirement for drawing wire from 100 kg coils (Fig. 2); handling time/coil and output per manshift as functions of drawing practice and coil weight (Fig. 3); tilting beam (Fig. 4) and vertical (below floor level) pay-offs (Fig. 5). Take-up reels for heavy coils (Figs. 6,7) and for slow speeds (patented wire) and high fill (Fig. 8); storing device for heavy coils of coarse wire. Trend toward continuous-line processing: processing times for 100 kg of 1 mm dia. galvanized rope wire (Fig. 10). Uniformity and reproducibility of mechanical properties (Figs. 11, 12). Cooling of wire-drawing blocks: present and future (Fig. 13). Finishes and protective coatings.] Price $12.60

5835 Investigation of the Process of Cooling of Wire Rod After Rolling in a Continuous Mill. V. I. Gubinskii, A. N. Minaev and N. Yu. Taits. IZVEST. VUZ- CHERN. MET., Nov. 1962, #11, pp. 128-32; 3 figs., 2000 words. [Report on industrial-scale trials aimed at lowering the present high oxidation losses of wire rod finish-rolled on high-speed mills. Magnitude of heat transfer as a function of the velocity of the cooling water and that of the wire rod, of the direction of water flow in, and the geometry of, the rod-guide tubing filled with water. Diagrammatic representation of cooling arrangements used for determining the most favorable cooling conditions for hot-rolled wire rod (Fig. 1). Changes in diameter of guide tubing, the method of delivery and direction of flow of the cooling water; also its speed of travel, as affecting the abstraction of heat. Determination of mean heat transfer coefficient over the length of the cooling path as a function of the absolute water velocity therein (Fig. 2). Derivation of laws governing the effect of the various factors on the heat transfer during forced movement of a liquid in tubes. Quantity of heat transferred from rod to cooling water, both simultaneously moving co-current, counter-current, and under spray + co-current (Fig. 3). Experimental results worked out in form of criteria: significant final equation for solution of problem.] Price $6.50

3050 Friction, Wear and Lubrication in Wire Drawing. W. Papsdorf. STAHL UND EISEN, vol. 72, 1952, #8, pp. 393-99; 10 figs., 2 tables, 4700 words. [Explanation of friction conditions based on latest research results. Conditions of lubrication in wire drawing and Heidebroek's concept of boundary friction. Dependence of coefficient of friction on velocity of sliding and on surface pressure. Scoring of wire-drawing dies; die wear. Dependence of viscosity of fatty oils and mineral oils upon temperature and pressure. Lubricants used in wire drawing. Importance of lubricant carrier, wire coating, and correct lime / soap ratio, particularly with metal soaps.] Price $9.40

3717 Phosphating of Wire and Wire Rod Preparatory to Cold Drawing and its Importance for the Wire Industry. L. Kuś. HUTNIK (Poland), vol. 22, 1955, #9, pp. 318-24; 5 figs., 6 tables, 1600-word condensation. [Selection of best available preparation for continuous phosphating operations at wire mills. Data on best-known German (6) and Russian (1) compositions for fast phosphating baths (Tables 1 and 2) for (a) starting new baths and (b) regenerating used baths; method of preparing baths. Procedure for selecting the most favorable phosphating bath and phosphating conditions (bath temperature; bath concentration; immersion time, etc.) giving optimum results. Drawing experiments on phosphated steel wire and rod (0.08 to 0.75% C); die diameters and percent reductions (Table 5). Drawing force required (Table 6) for phosphated as against nonphosphated wire and rod, and surface qualities obtained (Figs. 2-5).] Price $3.80

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Fundamentals of Drawing of Steel Wire- 6.

Order No.

2251 Feeler Device for Measuring the Shape of Wire Drawing Dies. H. Mucke. STAHL UND EISEN, vol. 68, 1948, No. 25-26, pp. 484; 1 figure, 1300 words. [Difficulties in checking precisely the shape of wire drawing die holes. Efforts at developing a self-recording device, particularly suited for holes less than 5/64 inch in diameter. Feeler device suggested by author (Figure 1); two variants.] $2.30.

2623 Drawing Experiments with Alloy Steel Wire Under Different Conditions. W. Lueg and A. Pomp. STAHL UND EISEN, vol. 70, 1950, No. 22, pp. 977-984; 7 figures, 3 tables, 5900 words. [Importance of good adhesion of lubricant to steel surface in cold drawing. Value of suitable lubricant carrier. Experimental arrangement. Steels drawn: Low Cr cold-drawn steel with spheroiditic structure; high speed steel (8½% W, 4 Cr, 1.8 V); and 18-8 steel with 0.5% Co + 0.5% Ti. Lubricants used: Dry soap and commercial drawing grease with addition of oil. Experimental program and procedure. Conditions of drawing selected for the different series. Evaluation of experimental data. Single-draft experiments with increasing percent reductions. Experiments involving sequences of 3-4 drafts and conducted under varied conditions of drawing. Experiments on the drawing of 18-8 Ti + Co steel involving an eight-draft sequence without process anneal. Advantage of an additional lubricant carrier to insure better adhesion of lubricant.] Price $11.40.

2179 Chemical Coatings for Improved Cold Shaping of Steel. W. Overath. STAHL UND EISEN, vol. 68, 1948, No. 13-14, 4300 words. [Technological importance of chemical coatings, especially metal phosphate coatings, for the cold shaping of steel. Phosphating practices. Explanation of phenomena observed in the most varied cold shaping operations, on the basis of the chemical and physical properties of metal phosphate coatings. Data on usefulness of phosphate coatings in the cold extrusion of steel parts, deep drawing of tubular parts, cold drawing of precision tubing, bar stock, and sections of steel, drawing of wire of high strength steel, and manufacture of steel screws. Advantages: Reduction of work of deformation; increase in number of passes without process anneal; improved surface quality of products; longer life of shaping tools; less expensive lubricants.] Price $7.55.

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Fundamental Factors in Rolling of Steel- 3.

Order No.

2861 Spread in the Hot Rolling of Steel. H. Bechmann. STAHL UND EISEN, vol. 70, 1950, #26, pp. 1222-3; 1 fig., 700 words. [Near-proportionality of ratio of spread/draft in rolling to root of ratio of roll radius/thickness of bar before pass, according to W. Tafel and H. Sedlaczek. Author's new approximation formula which is more accurate than Tafel and Sedlaczek's formula. Diagram (Fig. 1) from which the ratio of spread/draft can be read without calculations.] Price $1.90

2906 Distribution of Pressure over the Contact Area in Rolling. I. G. Astakhov. TRUDY MOSKOVSKOGO INST. STALI, im. I. V. STALINA, Symposium No. 30 on "Structure and Properties of Steel", 1951, pp. 147-180; 7 figs., 1 table, 1850-word condensation. [Investigation of variation of contact pressure in the rolling of metal strips having different widths. Experimental arrangement and procedure. Materials used for study: bronze, brass, steel, etc. Effect of strip width upon distribution and magnitude of contact pressure across strip. Influence of amount of cold reduction on contact pressure distribution in the direction of rolling. Effect of rolling speed and lubricant on character and magnitude of contact pressure between strip and rolls. Correlation between experimental and theoretical data; conclusions to be drawn.] Price $3.70.

4488 Apparatus for Drawing and Pull Rolling of Metals under High Hydrostatic (Liquid) Pressure. B. I. Beresnev and Others. TSVETNYE METALLY, vol. 31, 1958, #8, pp. 61-3; 2 figs., 1600 words. [Bridgman's work on drawing steel into wire under high hydrostatic pressures. Work done in the Soviet Union on the extrusion of metals by high-pressure liquids. Design of preliminary laboratory equipment for (a) drawing metals into wire (Fig. 1b) and (b) pull-rolling of metals (Fig. 1c), both under high hydraulic pressures. Design details of new laboratory apparatus (Fig. 2) developed for cold drawing and rolling -- currently of aluminum -- under pressures of about 10,000 kg/sq.cm (63.5 tsi). Principle of apparatus; its operation; steel compositions used for its most highly stressed parts.] Price $3.40

5192 Surface Defects on Rolled Steel. P. Ya. Ryzhkov and R. M. Shereshevskaya. METALLURG, May 1961, #5, pp. 25-26; 1 fig., 500 words. [Metallographic patterns of artifically produced surface defects on tube blanks as a potentially useful guide in identifying the nature of actual surface defects such as occur on rolled stock.] Price $2.25

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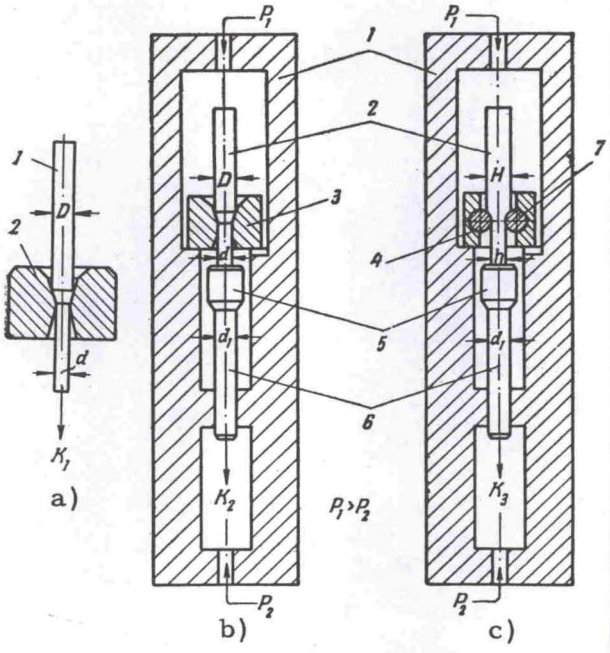


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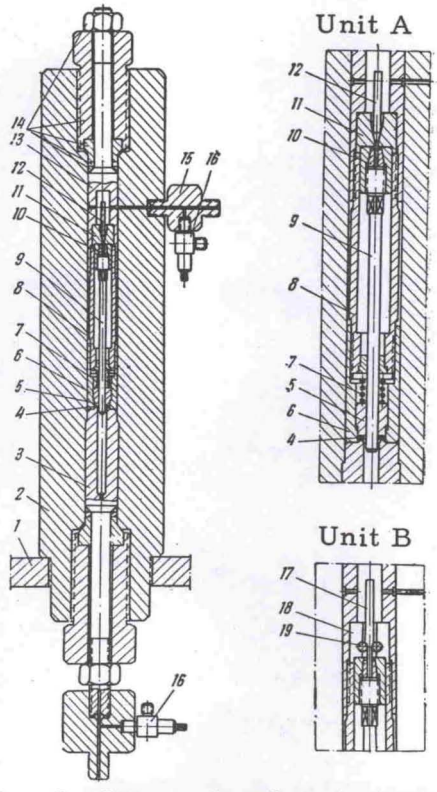


Fig. 2. Set-up for drawing and pull rolling of metals in pressurized liquid.