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FOREIGN TECHNOLOGY DIVISION

VOLUME STAMPING ON HYDRAULIC PRESSES

(Selected Portions)

by

A. F. Belov, B. V. Rozanov, V. P. Lints

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VOLUME STAMPING ON HYDRAULIC PRESSES
(Selected Portions)

By: A. F. Belov, B. V. Rozanov, V. P. Lints

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ë in Russian, transliterate as yë or ë.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

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Chapter III.

PRESSES FOR DIE FORGING OF LIGHT ALLOYS.

1. Constructions/designs.

The constructions/designs of the first stamping machines, created at the end of the 30th, the beginning 40's, as a rule, repeated the constructions/designs of powerful/thick forging presses, i.e., they were four-roll with the base parts in the form of the one-piece/entire or composite/compound castings of large mass. The production potentialities of the Heavy Machine Building Plants at that time did not make it possible to manufacture for the part of large masses and overall dimensions, than the part of press by effort/force 15000 T (Fig. 19). For example, column had a diameter along the thread 840 mm, and the length of 14480 mm, its mass was equal to 57.5 m; upper cross-beam consists of five casts: two mass on 40 m each and three - on 82 m each. Mobile and lower cross-beams were comprised of three casts each, moreover the mass of the greatest casting was equal to 105 m.

Press by effort/force 30000 T (Fig. 20) is made eight-column. It consists as of two presses each of which develops effort/force 15000 T. These presses are connected general/common/total - mobile and lower (by base/root) cross-beams, made from the powerful/thick cast beams/gullies. Diameter of columns 805 mm the length of 21200 m.

The characteristic of powerful/thick presses effort/force 15000 and 30000 T "Shleman" is given in Table 4 [29].

In France in 1939 by firm Schneider was constructed the first small stamping machine with effort/force 20000 T (Fig. 21), whose working cylinders were combined with four (of eight) columns. Remaining columns are attached in the lower cross-beam and are guides for the upper cross-beam. Press has two cross-beams, mass 645 m the operating pressure of liquid 500 kgf/cm². Sizes/dimensions of table 2500x1500 mm, the open height/altitude of 1500 mm, the greatest course 400 mm.

In England the firm Levi into the 30's put into operation of presses by effort/force 12000 T (Fig. 22): a number of working cylinders 3, the sizes/dimensions of table 3960x1830 mm, the open height/altitude of 3650 mm, the greatest course 3050 mm, the overall height of press 17100 mm.

In 1955 in the USA were started in the operation two presses by effort/force 31500 T and two by effort/force - 44500 T.

Firms United and Mesta at the plant of Alcoa (Pittsburgh) constructed respectively presses by effort/force 31500 and 44500 T (Fig. 23, 24), in which with some changes repeated the construction/design of press by effort/force 30000 T the firms Shleman.

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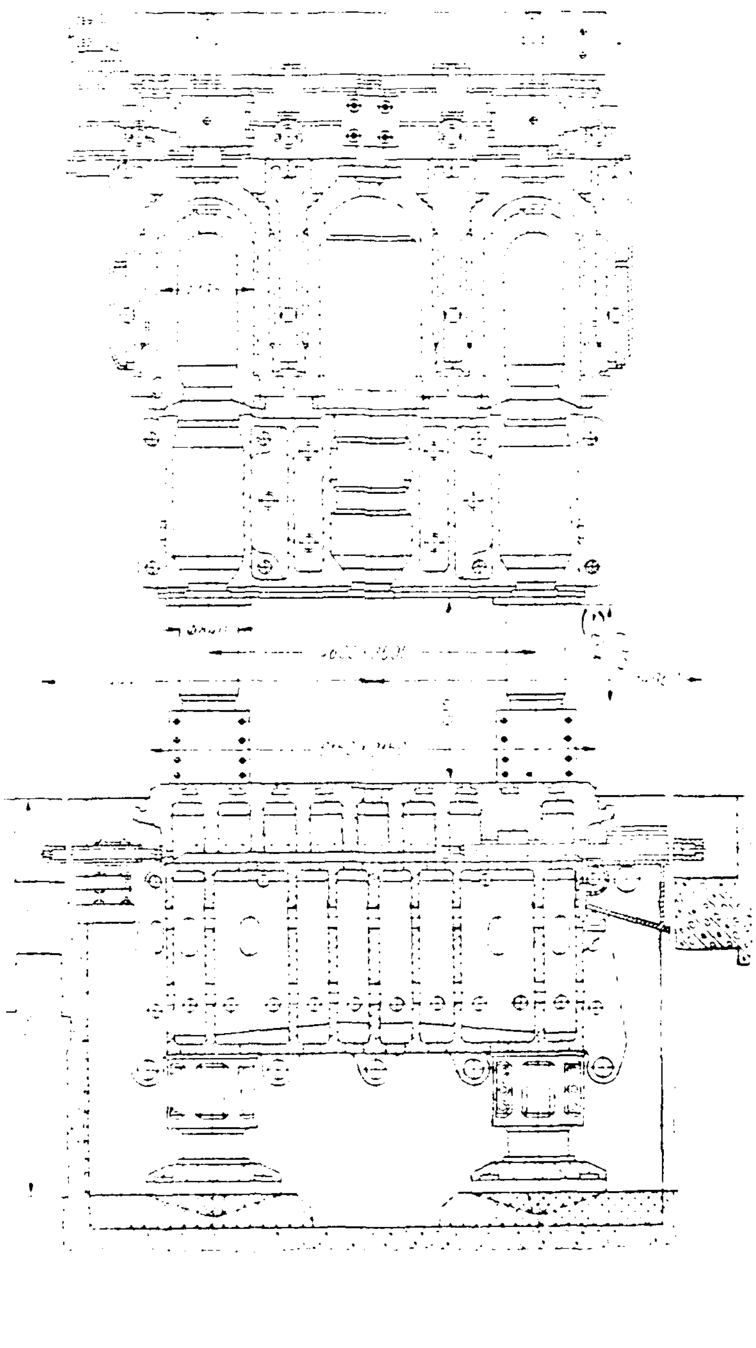

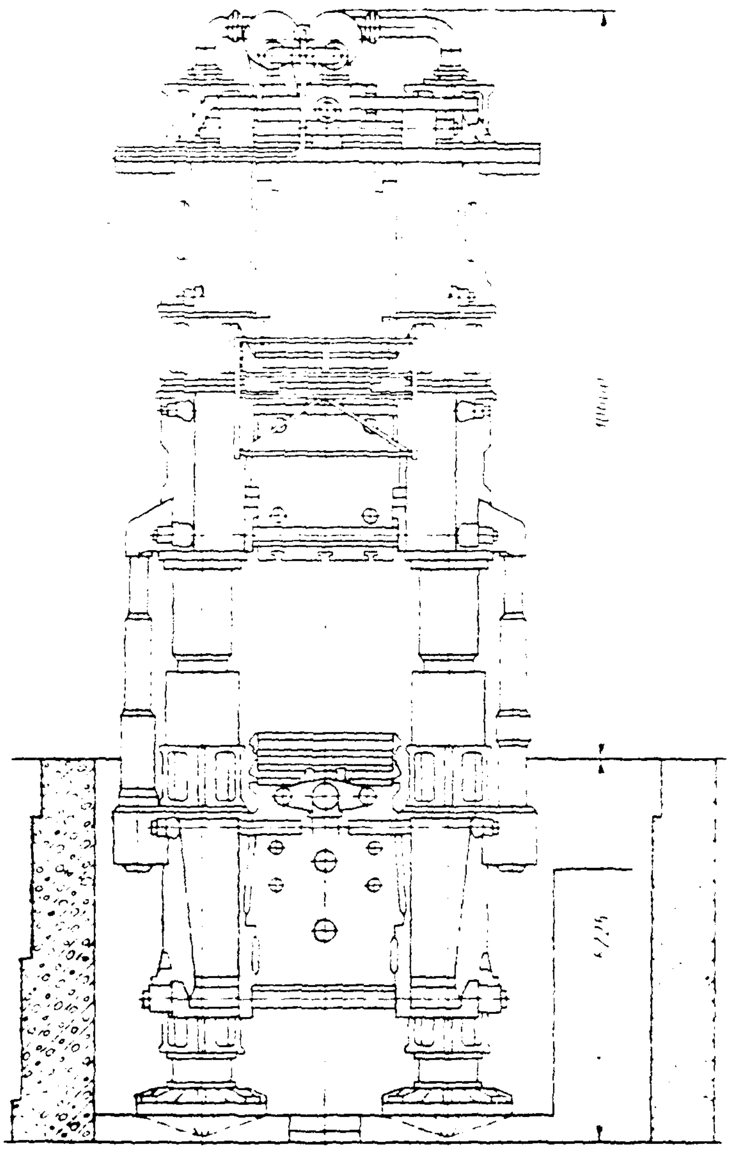

Fig. 19. Press by the effort/force 15000 T of firm Shleman [24].

Key: (1). Course.

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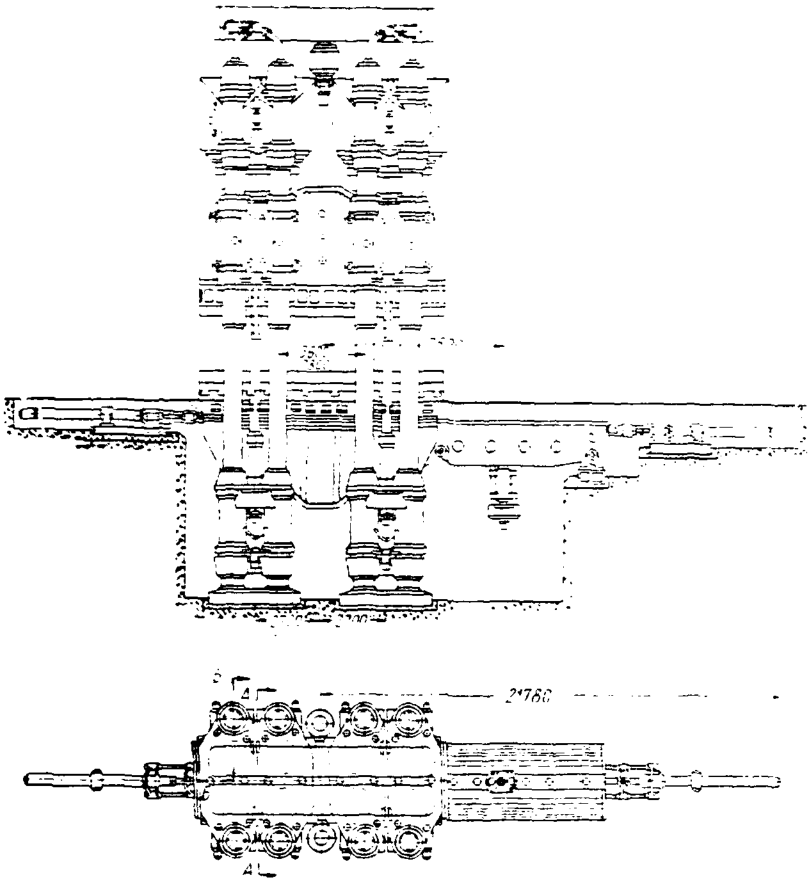

Fig. 20. Press by the effort/force 30000 T of firm Shleman [29].

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Firm Levi created the original construction/design of powerful/thick stamping machine, special features/peculiarities of which is the use/application of square strut- thrusts, assembled from the forged plates/slabs and transmitting effort by hammer heads for the cast cross bars. Basic cross-beams (mobile and base/root) are made in the form of bundles from forged plates/slabs.

Press by effort/force 31500 T (Fig. 25a) has four struts (two frames), while presses by effort/force 44500 T (Fig. 25b) - six struts (three frames). Each strut consists of three plates/slabs in mass 110 m each. The mass of each cross bar of press by effort/force 31500 T is 190 m, and press by effort/force 44500 T - 250 m.

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The working cylinders of these presses the cylinders of these presses are placed under the base/root, which is for them support. As a result to the effort/force, developed with working cylinders, is added another effort/force from the mass of press (besides table).

By the Soviet Machine Building Plants approximately/exemplarily at the same time, that also in the USA, were created the presses with effort/force 30000 and 75000 T. The construction of these presses preceded extensive research work on the study of technology of stamping and its effect on the loading of presses [24].

Table 4. Technical characteristic cf presses ty effort/force 15000 and 300CC T "Shleman".

(1) Параметры	(2) Пресс усилием в Т	
	30 000	15 000
(3) Давление рабочей жидкости в кГ/см²	450	320
(4) Число рабочих цилиндров	8	3
(5) Размеры стола в мм	10 000 · 3400	6150 · 2150
(6) Открытая высота в мм	2700	2500
(7) Наибольший ход в мм	1800	1400
(8) Габаритные размеры пресса в мм:		
(9) в плане	10 000 · 6500	8500 · 5850
(10) высота над уровнем пола	16 400	10 600
(11) общая высота	24 620	15 825
(12) Масса пресса в т	5 200	2 000

Key: (1). Parameters. (2). Press ty effort/force in T. (3). pressure of working fluid in kgf/cm². (4). Number cf working cylinders. (5). Sizes/dimensions of table in mm. (6). Open height/altitude in mm. (7). Greatest course in mm. (8). Overall dimensions cf press in mm. (9). in plan/layout. (10). height/altitude above flccr level. (11). overall height. (12). Mass cf press in m.

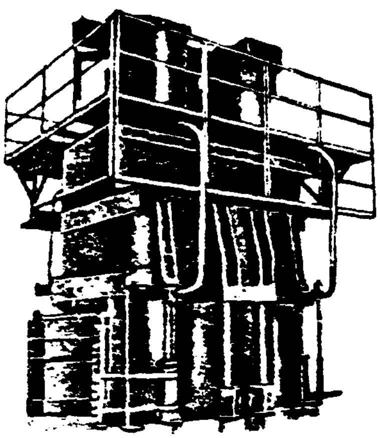

Fig. 21.

Fig. 22.

Fig. 21. Press by effort/force 20000 T of firm Somua.

Fig. 22. Press by effort/force 12000 T of firm Levi [30].

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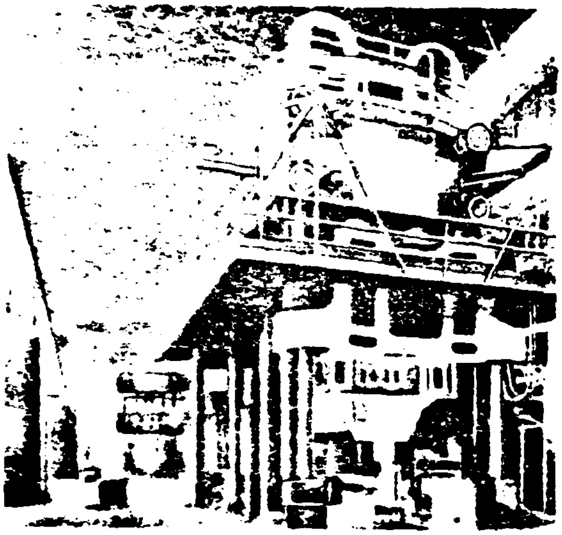

Fig. 23. Press by effort/force 31500 T of firm of United [48].

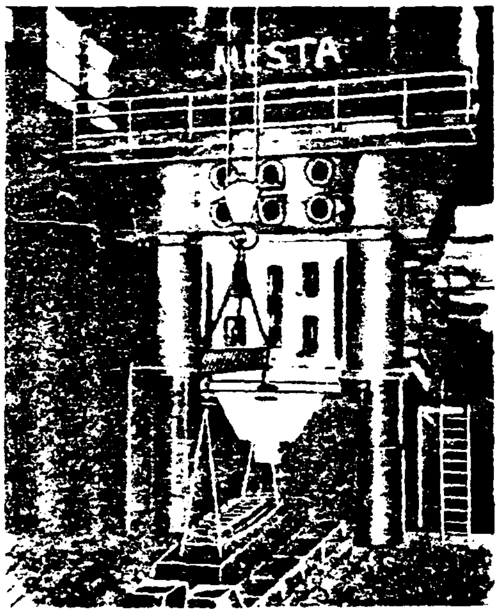

Fig. 24.
Press by the effort/force 44500 T of the firm of place [48].

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The technical characteristic of the hydraulic presses, constructed to the USA, is given in Table 5 [29].

These investigations showed that the used by foreign firms constructive solutions do not satisfy the requirements of obtaining on the presses of the precision die-forged forgings. None of the described constructions/designs for the powerful/thick presses by the effort/force of more than 45000 T could be used as a result of the fact that preparation of their parts was limited to the possibilities of the Heavy Machine Building Plants.

As it will be shown, the effect of the construction/design of press on the precision/accuracy of the die-forged forgings in essence is developed in the deviations of their thickness due to joint elastic deformation of cross-beams, die base-plates and die/stamp, elastic warping of dies/stamps and under-stamping blocks, and also of rotation of the crosshead with the eccentric loading and corresponding misalignment of the upper die.

Therefore assemblies and parts of the powerful/thick stamping machines, created with Soviet industry, have the increased rigidity; for warning/preventing the misalignments of the crosshead with its eccentric loading are used special systems.

The mounting of stamping hydraulic machine by the effort/force 30000 T of UZTM [Ural Heavy Machinery Plant] (Fig. 26) has column construction/design. The sizes/dimensions of effective area of bolster are 10000x3300 mm, the open height/altitude of 3000 mm, the greatest course of the crosshead 1500 mm.

Table 5. Technical characteristic of stamping hydraulic machines by effort/force 31500 and 44500 T, constructed in the USA.

(1) Параметры	(2) Пресс усилием в Т			
	31 500		44 500	
	(3) «Юнайтед»	(4) «Леви»	(5) «Места»	(4) «Леви»
(6) Давление рабочей жидкости в кГ/см²	315	315	315	315
(7) Число рабочих цилиндров	8	6	16	9
(8) Размеры стола в мм	8220 2100	9300 3660	7925 3660	9900 3700
(9) Открытая высота в мм	3350	3600	—	4200
(10) Наибольший ход в мм	1830	1830	1830	1830
(11) Габаритные размеры пресса в мм:				
(12) высота над уровнем пола	10 000	14 000	15 544	15 000
(13) общая высота	21 945	34 000	26 520	35 000
(14) Масса пресса в т	5200	—	—	—

Key: (1). Parameters. (2). Press by effort/force in T. (3). "United". (4). "Levi". (5). "Places". (6). Pressure of working fluid in kgf/cm². (7). Number of working cylinders. (8). Sizes/dimensions of table in mm. (9). Open height/altitude in mm. (10). Greatest course in mm. (11). Overall dimensions of press in mm. (12). height/altitude above floor level. (13). overall height. (14). Mass of press in m.

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In press eight working cylinders. The extensible table, designed for the load 600 T, has a course 8000 mm. For the removal/distance from the die/stamp of finished articles is a system of knockouts.

The crosshead and the base/root of the press of UZTM in contrast to the press "Shleman" of the same effort/force are made from the bundles of the rolled plates/slabs with a thickness of 200 mm, fastened by pins.

In order to facilitate the work of eight columns in the case of the misalignment of the crosshead, in its guides are used the elastic elastic bushings, which partially unload columns from the bending moments.

Upper cross-beam is made composite from four welded-cast beams/gullies in mass 128 m each, manufactured with the aid of electroslag welding. The beams/gullies, fastened in pairs, form the three-dimensional/space construction/design which seemingly consists of two independent parts.

The framing of columns in the upper cross-beam and in the cross beams of the base/root of mounting is realized with the aid of the split spacer bushings, which eliminates displacement or rotation of columns in the bearing edge.

The installation/setting up of press on the foundation is realized with the aid of four supports with the spherical pillows in the upper part. The elastic pliability/compliance of supports and the rotation of spherical pillows prevent/warn the emergence of the increased loads on the foundation and mounting in the case of the thermal deformations of the latter with the work of press.

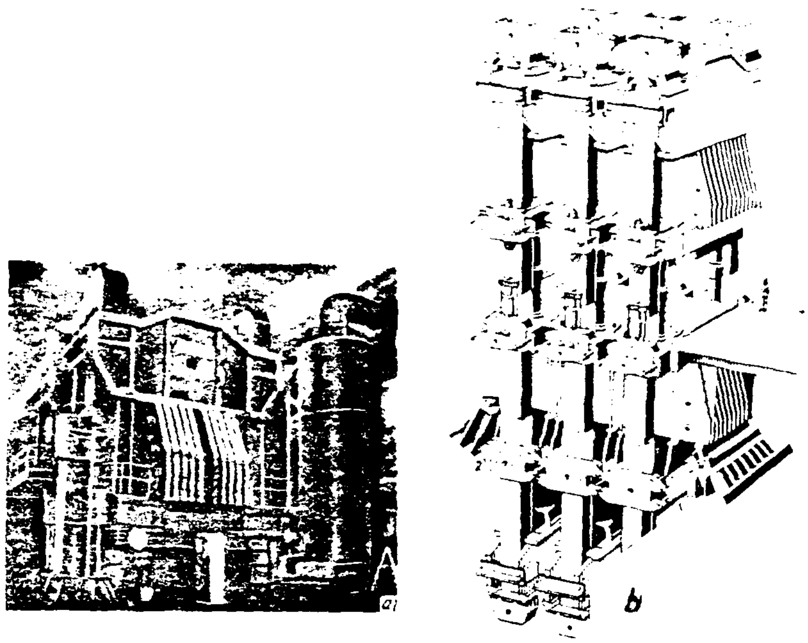

Fig. 25. Press of firm Levi by the effort/force: a) 31500 T [50]; b) 44500 T [29].

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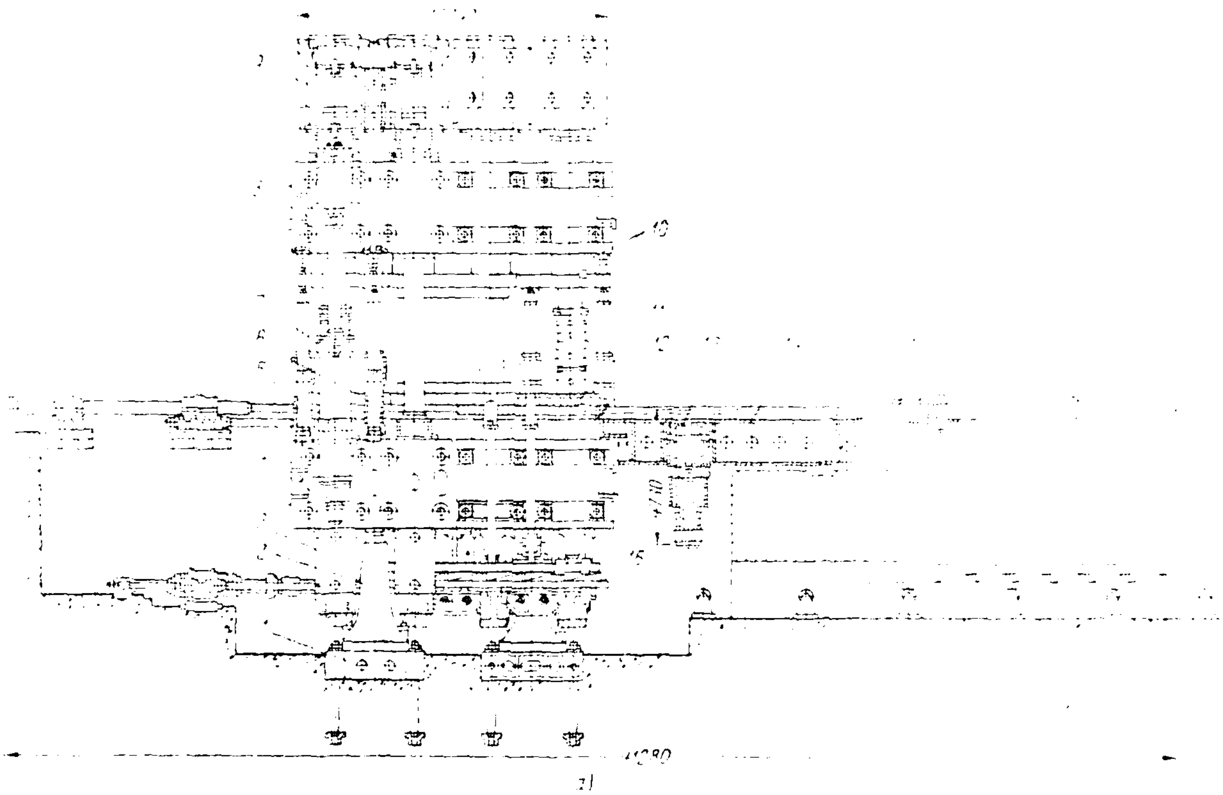

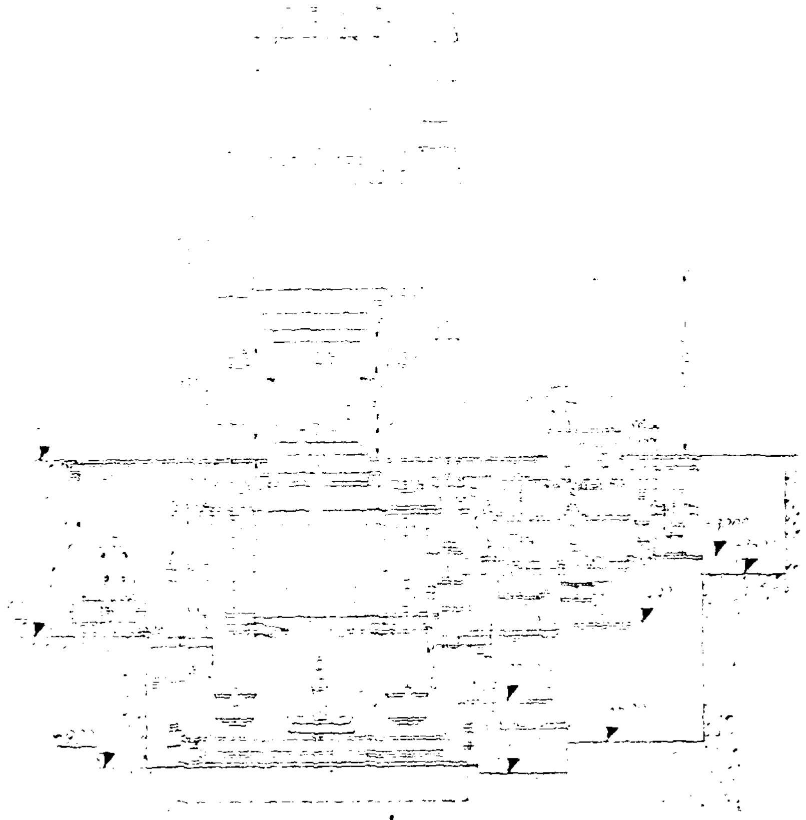

Fig. 26. Press by the effort/force 30000 T of the UZTM: a) front view; b) side view [44]; 1 - base plate; 2 - strut; 3 - cross beam; 4 - cover plate of lower cross-beam; 5 - hoisting cylinder; 6 - balancing cylinder; 7 - leveling cylinder; 8 - the crosshead; 9 - upper cross-beam; 10 - transverse plates/slabs of the crosshead; 11 - extensible table; 12 - pillow; 13 - side knockout; 14 - bridge of table; 15 - cylinder of the movement of table; 16 - central knockout.

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One of the special features/peculiarities of this press is mechanization of all technological operations of stamping, beginning from the procedure of blanks of the furnace and ending with packing finished articles to the cooler. For supply and removal/distance of blanks are established/installed two lines of mechanisms.

Fundamentally different is the construction/design of the largest in the world press by effort/force 75000 T (Fig. 27). The mounting of press consists of four frame sections. Sections are connected with below fixed cross-beam, and on top - by powerful/thick beams/pullies (longitudinal connections/communications), arranged/located on the different levels.

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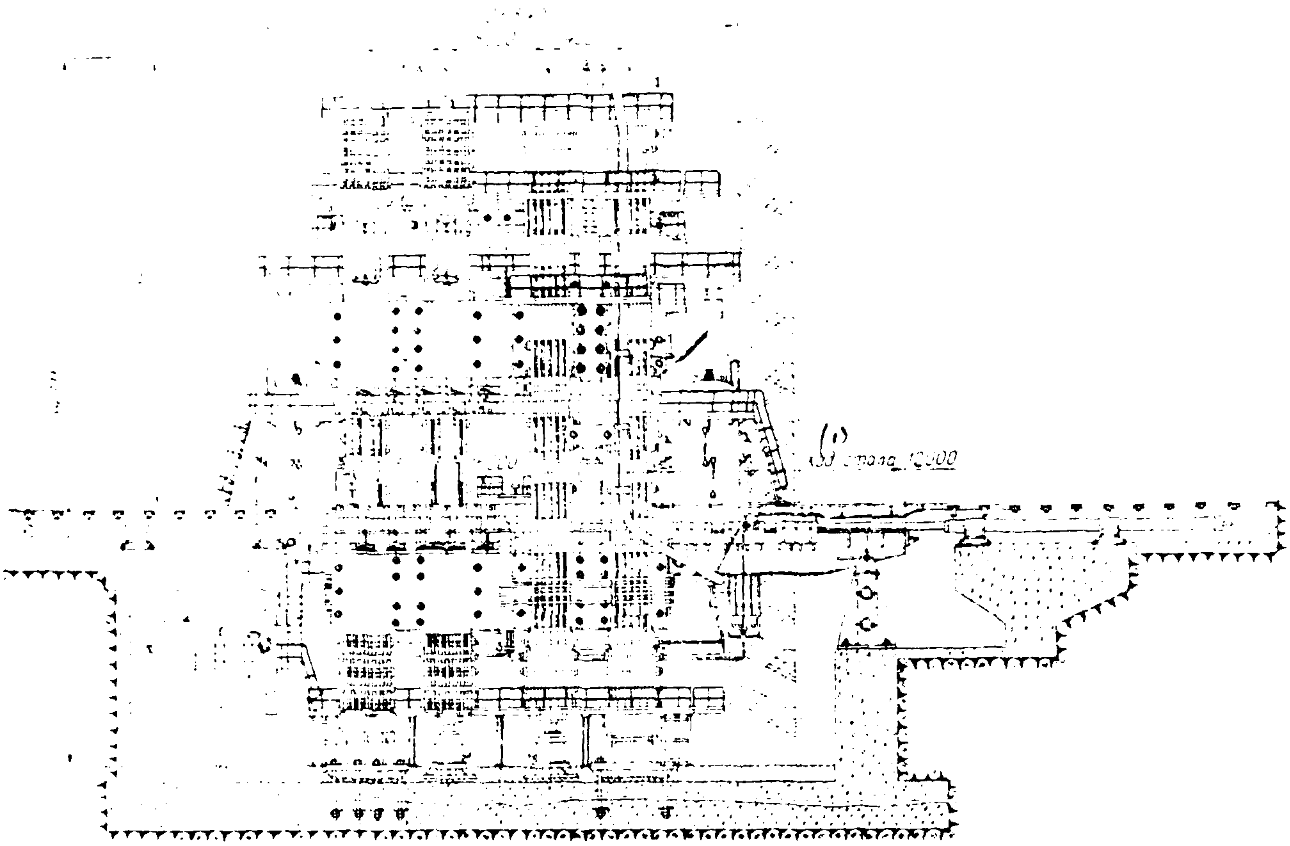
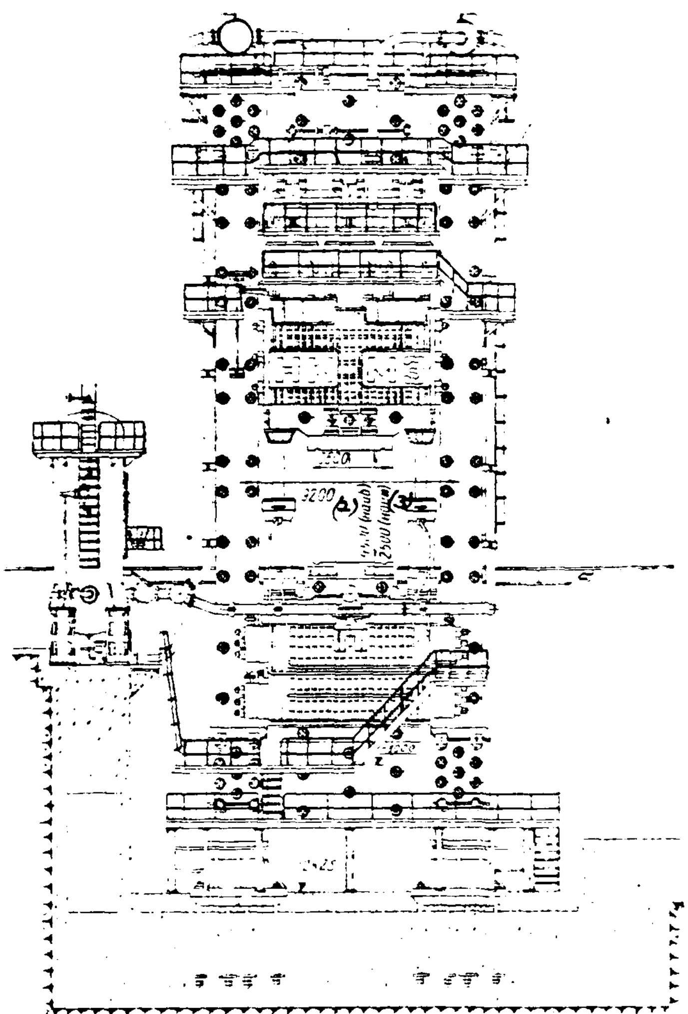


a)



b

Fig. 27. Press by effort/force 75000 T [30]: a) front view; b) side view.

Key: (1). Course of table. (2). (max). (3). (min).

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In order to ensure the uniform loading of table and crosshead, that have large area, press is made 12-cylinder (3 cylinders in each section).

For the direction of the crosshead during the idling, and also, in order to take the appearing during the stamping horizontal efforts/forces, are provided for four circular columns, rigidly connected with the crosshead and which slip in the guiding supports, which are simultaneously connections/communications of frames. The recurrent course of the crosshead is accomplished/realized by eight cylinders, four of which are controlled, and the others are constantly connected with the pump-and-battery station.

The mounting of press rests on the foundation through four spherical pillows, established/installed under the outer frames, and four hydraulic jacks, established/installed under the average/mean frames. Jacks are intended for decreasing the sagging/deflection of fixed cross-beam from their own mass and absorption of its oscillations during unloading of press.

Press is equipped by the knockouts, established/installed in the upper and lower under-stamping blocks, and also by the complex of mechanization, which foresees the supply of blanks to the press, their packing into the die/stamp and removal/distance after stamping. Basic parameters of the press: the overall dimensions of table 16000x3500 mm, the open height/altitude of 4500 mm, the greatest course 2000 mm.

Characteristic feature of this unique press is the fact that the parts of its mounting and crosshead are assembled from the rolled welded plates/slabs. Cross bar (horizontal part of the section) consists of seven plates/slabs in thickness of 180 mm each, and strut (vertical part of the section) - of six plates/slabs in thickness of 200 mm each. The plates/slabs of cross bars and struts are tightened by the pins with a diameter of 100 mm. Mobile and lower (base/root) cross-beams are assembled from the plates/slabs in thickness to 400 mm, tightened by pins. Working cylinders are made welded-forged with the support to the bottom, which provides their strength.

The mass of parts from the plates/slabs, manufactured from rolled stock, composes 65o/o, but castings do not exceed 7o/o of general/common/total mass of press. Because of this the specific prime cost of press by effort/force 75000 T proved to be considerably lower than the presses of common column construction/design.

The manufacture of press by effort/force 75000 T to a considerable degree contributed to further development of technology of heavy machine building. In the process of the creation of this press were improved and mastered electroslag welding of very thick metal, electroslag girth welding, ultrasonic quality control of welded joints, strain/work hardening the heavily loaded elements/cells by percussive work hardening/peening, the methods of the roughing and finish processing of large-size parts on the stands and much other [25].

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For all described presses are characteristic the large sizes/dimensions of stamp space and the high value of working stroke, which predetermines their use for the diverse processes of the deformation of the large-size blanks of different typical dimensions. These presses are capable of completely ensuring the manufacture of the articles of the frequently changing nomenclature. Such presses can be described as general-purpose.

The increasing necessity for the die-forged forgings led to the creation together with the general-purpose ones and the specialized presses. The fact is that large the mass and the cost/value of general-purpose presses could not but affect the cost/value of the manufactured large-size articles. At the same time there is a group of parts of the relatively small sizes/dimensions for manufacturing which can be used the presses with the low sizes/dimensions of stamp space and the small courses of the crosshead. In the specialized press installations/settings up due to the decrease of the nomenclature of the manufactured articles it is possible to attain the considerable decrease of overall dimensions, mass and cost/value of machines, periods of their input/introduction into the operation, increase in the productivity, reduction/descent in the operating costs.

The paramaters of the first powerful/thick small specialized presses, created to the USSR, are given in table 6 [15, 26].

In these presses is used the mounting of tube construction/design, which is simultaneously actuating cylinder. In the press by effort/force 15000 T (Fig. 28a) the mounting is made one-piece/entire, while in the press by effort/force 30000 T (Fig. 28b) - split, tightened by pins. In the presses extensively are used large forgings of the high-alloy steel whose production was for the first time mastered during the manufacture of these presses.

Table 6. Technical characteristic cf the specialized small stamping hydraulic machines by effcrt/force 15000 and 30000 T.

(1) Параметры	(2) Пресс усилием в Т	
	30 000	15 000
(3) Давление рабочей жидкости в кГ/см²	1000	1000
(4) Число рабочих цилиндров	1	1
(5) Размеры стола в мм	2500 1500	1500 1000
(6) Открытая высота в мм	1500	1000
(7) Наибольший ход в мм	350	250
(8) Габаритные размеры пресса в мм		
(9) в плане	4750 3750	3800×3500
(10) высота над уровнем пола	4925	3400
(11) общая высота	11 415	7800
(12) Масса пресса в т	807	340
(13) Масса прессовой установки в т	1300	[illegible]

Key: (1). Parameters. (2). Press ty effort/force in T. (3). Pressure of working fluid in kgf/cm². (4). Number cf wcrking cylinders. (5). Sizes/dimensions of table in mm. (6). Open height/altitude in mm. (7). Greatest course in mm. (8). Cverall dimensions of press in mm. (9). in plan/layout. (10). height/altitude abcve flccr level. (11). overall height. (12). Mass cf press in m. (13). Mass of press installation/setting up in m.

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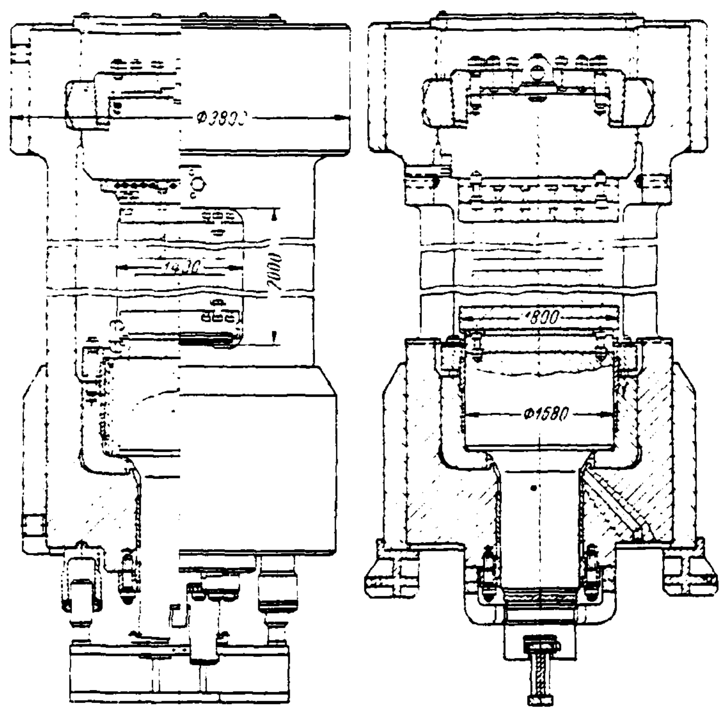
The distinctive special feature/peculiarity of the presses indicated is also the use of an elevated pressure of working fluid (1000 kgf/cm²), that also made it pcssible to fulfill by their small ones. However, if with the use/application of presses of such constructions/designs are solved questions of a reduction/descent in cost/value and increase in the productivity, then are not solved the problems of an increase in the precision/accuracy of stamping.

During the creation of the construction/design of the single-cylinder specialized presses approached elimination during the loading of such shortcomings as sagging and the misalignments (stamp set of such presses is fastened directly to the plunger of working cylinder).

The saggings/deflections of cross-beams, as it will be shown, have secondary value for the precision/accuracy and in the general-purpose presses. The at the same time elastic warping of die/stamp appears also in the specialized presses, and its nonuniformity with the eccentric loadings, including the misalignment of moving elements, reaches 2.5 mm/m (with the eccentricity 150 mm). The fact is that in contrast to the general-purpose ones the created specialized presses are not equipped by the devices, which automatically eliminate the misalignment of moving elements with the eccentric loading.

The constructions/designs of powerful/thick stamping machines, developed in the 60's, they indicate the appearance of a tendency toward the creation of machines with the smaller metal content, but from the parameters, which obtain satisfaction with their sufficiently general-purpose ones.



a

Fig. 28. Presses of NKMZ-VNIIMETMASh by the effort/force: a) 15000 T [15]; b) 30000 T [26].

Key: (1). Course.

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Thus, the design concept of press by effort/force 30000 T with the cylinders, arranged/located directly on the columns (Fig. 29) [2], does not have upper cross-beam in the common understanding of this word, since the latter is simultaneously and the crosshead. All this made it possible to lower the mass of press with the retention/preservation/maintaining of free access to the dies/stamps and conveniences in their maintenance/servicing. A press can be utilized for obtaining the articles in height to 800 mm. In the presses of this construction/design important value acquires the work of the leveling system, since the moments/torques from the eccentric load application can lead to the inadmissible increase in the stresses/voltages in the basic elements/cells of press.

Technical characteristic of press by effort/force 30000 T.

Pressure of working fluid in kgf/cm² ... 320

Number of working cylinders ... 4

Sizes/dimensions of table in mm ... 1500x2500

Open height/altitude in mm ... 3100

Greatest course in mm ... 800

Overall dimensions of press in mm:

height/altitude above the level of the floor ... 8300

overall height ... 13300

Masses of press in m ... 1150

Masses of press installation/setting up in m ... 1500.

The mounting of single-cylinder press by the effort/force 30000 T of the firm of hydraulics (Fig. 30), put into use in the FRG (1964), is made in the form of the frame, which consists of four bundles of rolled plates/slabs with the cutouts for the installation/setting up of upper and lower cross-beams [53].

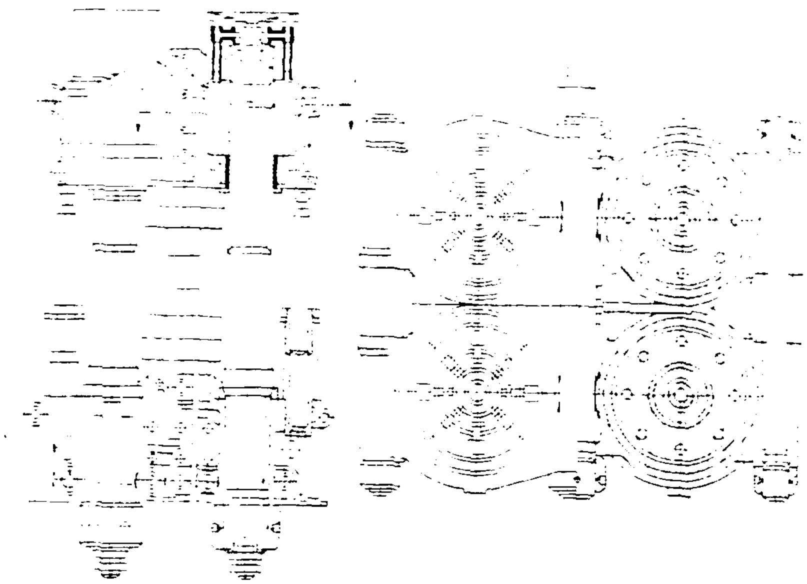

Fig. 29. Press by the effort/force 30000 T of Novosibirsk plant "Tyazhstankogidropress [Heavy Machine Tool and Hydraulic Press Plant]" im. A. I. Yefremov [2].

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The latter cast integral in mass on 180-200 m each (in the untreated form). Stepped plunger with the maximum/overall diameter of 2800 mm, as it is confirmed in work [53], has reliable direction in master cylinder. The crosshead re-set by means of four reverse/inverse cylinders, arranged/located out of the mounting and attached in the upper cross-beam.

Press is equipped by extensible table and bottom knockout. On the table is established/installed auxiliary horizontal press by effort/force 1000 T, which ensures the possibility of obtaining the die-forged forgings with the side cavities and the local thickenings (similar device exists on the press by the effort/force 31500 T of "United"). Basic parameters of the press of the firm of the hydraulics: the pressure of working fluid 500 kgf/cm², a number of working cylinders - 1, the sizes/dimensions of table 5000x2000 mm, the open height/altitude of 2500 mm, the greatest course 1000 mm.

In 1965 in France by firm ASV was manufactured the press with effort/force 20000 T (Fig. 31a) with two crossheads. Two working pressure cylinders (upper by effort/force 13300 T and lower by effort/force 6700 T) located along its axis/axle. The pressure of liquid compose 600 kgf/cm², sizes/dimensions of table 3000x2000 mm, the open height/altitude of 2500 mm, the greatest course 1000 mm. The same firm developed the design even of more powerful/thicker press (Fig. 31b) [52]. As the basis of project is assumed the same principle of construction/design, as for the press by effort/force 20000 T. Difference lies in the fact that the mobile and fixed frames of mounting are made from the set of rolled plates/slabs. Vertical plates/slabs are connected with the horizontal ones with the aid of the conical rods, inserted into the bushing and by locked nuts.

For the manufacture from titanium alloys, the high-temperature (strength) and high-melting materials and made of high-strength steel of the die-forged forgings of intricate shape, which have the internal cavities, which mutually intersect at different angles, by firm Cameron pump (USA) were constructed two presses with effort/force 20000 T and 30000 T (Fig. 32) [54, 47].

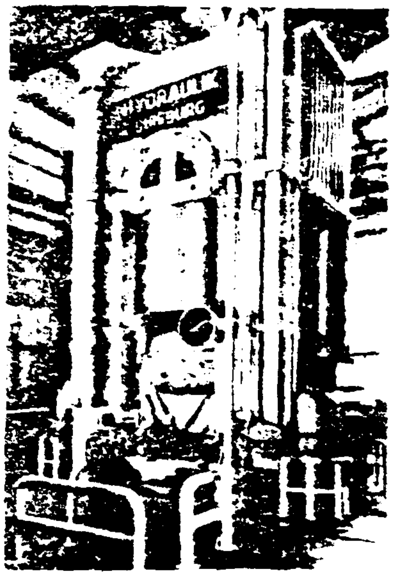

Fig. 30. Press by the effort/force 30000 T of the firm of hydraulics [53].

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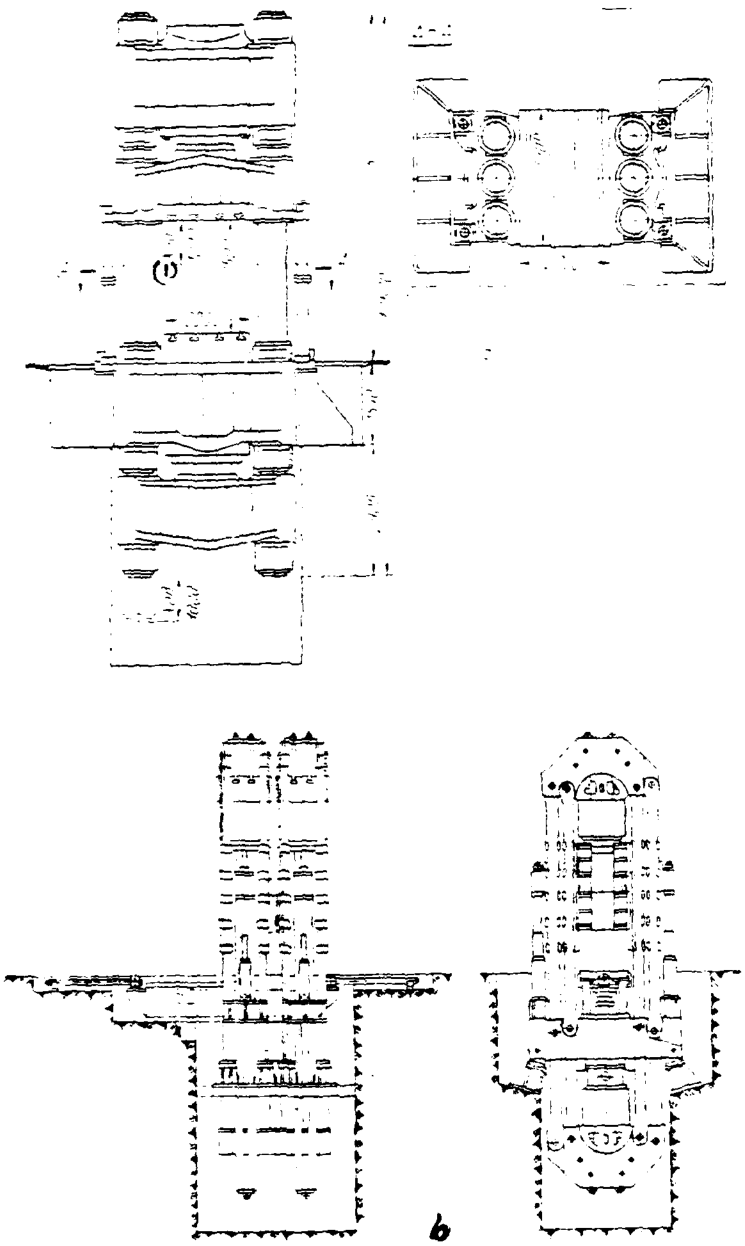

Fig. 31.

Fig. 31. Presses of firm ASV (France): a) by effort/force 20000 T; b) lamellar construction/design (project).

Key: (1). Course.

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These presses have besides vertical ones and horizontal working cylinders, and also additional vertical piercing cylinder. Thus, press by effort/force 20000 T is equipped by two horizontal cylinders (besides eight working cylinders) by effort/force 5000 T each and by piercing cylinder by effort/force 4200 T [54]. Under floor is assembled the cylinder of knockout, which develops effort/force 65 T. The effort/force of hoisting cylinders is 940 T. The frame of press consists of 12 plates in mass 60 m each. The general/common/total mass of press is 1525 m. It should be noted that both of presses have the large working course (press by effort/force 20000 T - 2250 mm, by effort/force 30000 T - 3000 mm). Presses can be used for pressure forging of thick-walled ducts/tubes/pipes. For example, on the press by effort/force 20000 T it is possible to obtain ducts/tubes/pipes in maximum outside diameter 900 mm and in length to 9 m [47], and on the press by effort/force 30000 T - ducts/tubes/pipes in maximum outside diameter 1220 mm and in length to 12 m (thickness of wall 20-150 mm).

The tendency to raise the precision/accuracy of the manufactured articles and to simultanecusly apply ever stronger materials leads to an increase in the required specific efforts for the working surface of die/stamp and, consequently, alsc to the decrease of sizes of forging, whcm can be manufactured on this equipment. Appears need in the creation of the presses cf even greater efforts/forces than being in the industry.

In the USA are published the specifications of press by effort/force 200000 T (Fig. 33) [3, 52]. The technolcgical possibilities of this press characterizes curve in Fig. 34 [16]. Are assumed that the sizes/dimensicrs cf the table of this press will be 9700x6000 mm, the open height/altitude of 750C mm, and the greatest course 5000 mm, overall height ~50 cf m. Press is designed single-cylinder (cylinder bore 50C mm). In the project are laid the following velocity parameters: the velocity of idle and back strokes 150 mm/s, the average speed cf working stroke 50 mm/s.

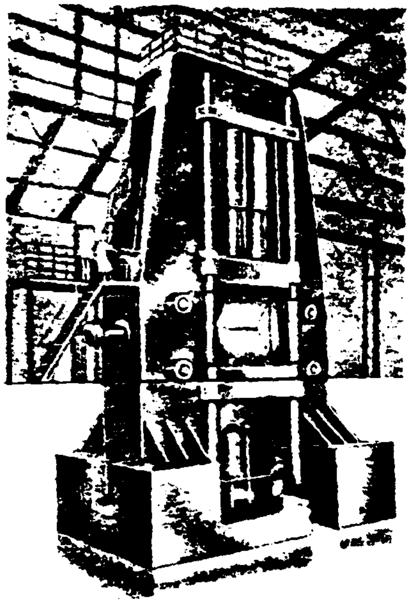

Fig. 32. Press by the effcrt/force 300000 T cf firm Camercn pump [54].

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However, in the cpinicn cf the authors of this bcok, the realizaticn cf this ccnstructicn/design is highly improbable and it is inexpedient. The creaticn cf the cylinder from the separate lamellar sectors, which wculd ensure effort/fcrca 20000 T, is problematic.

On the single-cylinder presses (as showed experience of operating the described above presses by effort/force 15000 and 30000 T) with more difficulty to obtain the necessary precision/accuracy of the die-forged forgings. The operation of press by effort/force 200000 T would cause enormous difficulties.

In connection with the necessity for the presses of large efforts/forces, but low overall dimensions, it is necessary to find new constructive solutions on the basis of the accumulated experience and the possibilities of the contemporary Heavy Machine Building Plants.

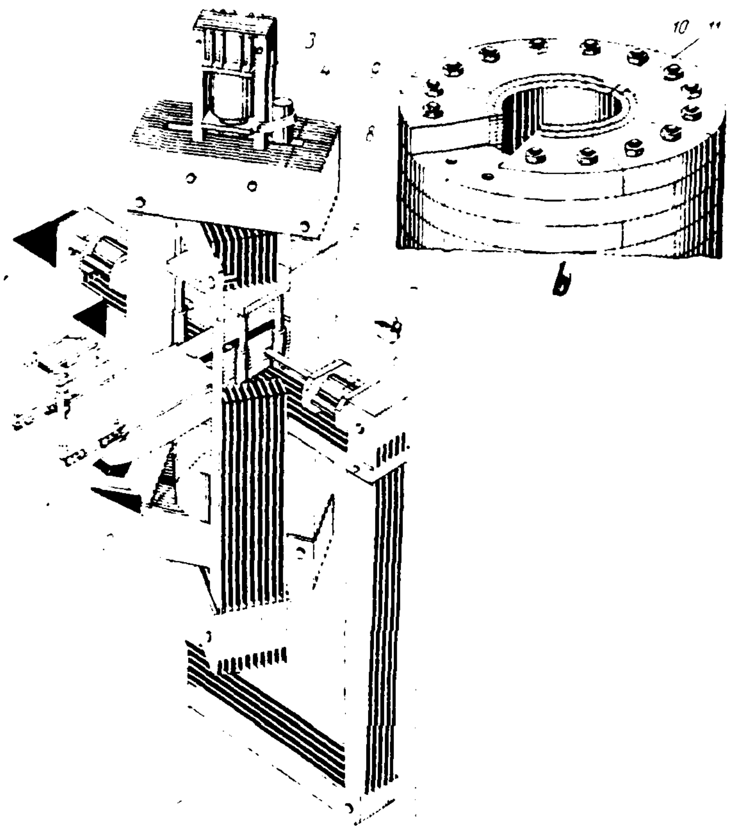

Fig. 33. Press by the effort/force 200000 T of firm Earogenics (design): a) the construction/design of press; b) composite/compound working cylinder; 1 - table; 2 - working cylinder; 3 - piercing cylinder; 4 - external frame; 5 - internal frame; 6 - side cylinder; 7 - control panel; 8 - tightening bolts; 9 - segments; 10 - steel bushing; 11 - lead bushing.

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This problem became by especially sharp/acute in connection with ever wider application of steel, titanium and high-temparature (strength) alloys, where still recertly as the structural material completely ruled aluminum.

New prospects in the construction of presses open/disclose the use of a mounting, with the fastered winding from the high-strength tape or the wire (Fig. 35) [4]. Cold-rolled tape has a yield point at a normal temperature of 190-300 kg/mm², whereas highest-quality large forgings 100-120 kg/mm². This makes it possible to considerably lower the ratio of the mass of machine to the effort/force in comparison with the same for the presses, at the basis of construction/design of which is laid column or frame diagram.

Furthermore, in this construction/design of press to the elongation works only high-strength tape. The cast or forged struts and cross bars are strained of compression.

The investigations, carried out in VNIIMETMASh All-Union Scientific Research, Planning and Design Institute of Metallurgical Machinery] [23], showed that under such loading conditions it is possible to sharply raise allowable stresses, up to the yield point (Fig. 36). Appears the possibility of applying the forgings and even cast made of common structural steels, well mastered by industry, for manufacturing of struts and cross bars.

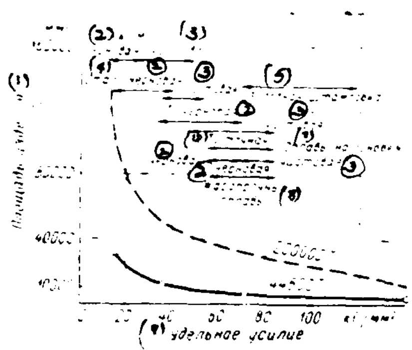

Fig. 34.

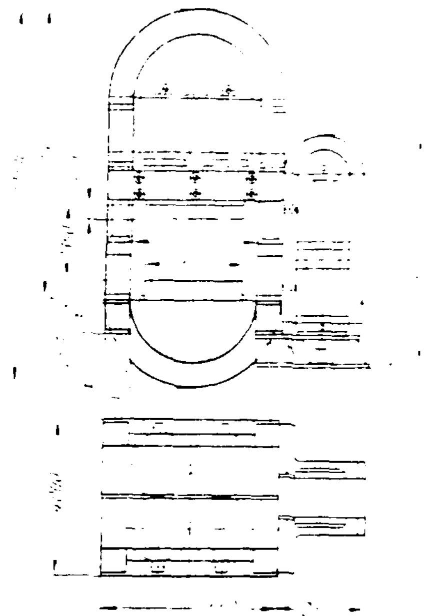

Fig. 35.

Fig. 34. Graph, which characterizes technological possibilities of presses by effort/force 200000 and 44500 T (required specific efforts/forces depending on area of article) [16].

Key: (1). Area of article. (2). Roughing. (3). Clean/finishing. (4). Steel. (5). Cold pressing. (6). precise. (7). Alloys on basis. (8). High-temperature (strength) alloys.

Fig. 35. Diagram of installation of press by effort/force 30000 T with stand, fastened high-strength tape: 1 - press; 2 - multiplier,

which develops pressure 1200 kgf/cm^2.

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Therefore in the construction/design of press with the fastened mounting the mass ratio to the effort/force will be less than in the press of tube construction/design (for example, for the press by effort/force 30000 T 3 times). The use of this design concept will make it possible to create even the more powerful/thicker specialized small lightened presses.

2. Velocity parameters, drive and administration.

The creation of the hydraulic stamping machines, which develop large efforts/forces, required the solution of many questions, connected with calculation and construction of drive and controls. These questions arose in connection with a sharp increase of the plant capacities and sizes/dimensions of the elements of hydraulic systems and, as a result, by the complication of servicing equipment.

The averaged values of the velocity parameters and driving power of contemporary stamping machines are given in Table 7.

The relatively high operating speeds of the motion of cross-beam and the respectively greater consumption of liquid per unit time cause use/application in the system of the drive of the press of the storage batteries/accumulators of high-pressure liquid. The velocity of the motion of cross-beam in this case depends on the resisting force to deformation and its change in the course of cross-beam, and also on losses of head in the main line.

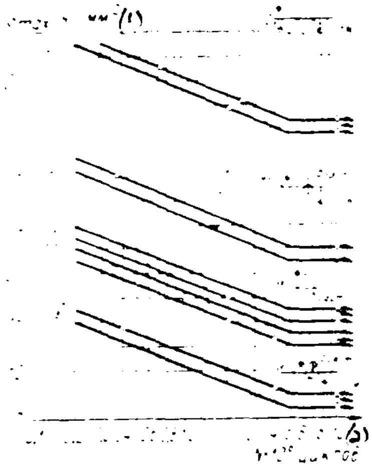

Fig. 36. The results of fatigue tests for compression of large-size samples/specimens made from steel 35L during different cycles of loading [23]: I - pulsing compression; II - pulsing compression with the elongation; III - pulsing elongation; IV - alternating symmetrical cycle.

Key: (1). kg/mm². (2). cycles.

Table 7. Parameters and the driving power of stamping machines.

(1) Пресс усилием в Т	(2) Скорость в мм/сек: (6) холостого и возвратного ходов	(2) Скорость в мм/сек: (7) рабочих ходов	(3) Рабочее давление насосно-аккумуляторной станции в кГ/см²	(4) Суммарная подача в л/мин и мощность насосов в квт	(5) Маневровый объем аккумулятора в м³
15 000	150	50	320	2000 1400	1500
30 000	150	50	320	3000 2100	3000
45 000	150	50	320	4000 2800	4500
75 000	120	50	320 200	5000 3500	(8) 9000 (две секции)

Key: (1). Press by effort/force in T. (2). Velocity in mm/s. (3).

Operating pressure of pump-and-battery station in kgf/cm². (4). Total supply into 1/min and lifting power in kW. (5). Maneuvering volume of storage battery/accumulator in m³. (6). idle and recurrent courses. (7). working strokes. (8). (two sections).

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The most precise calculation of the velocities of the motion of cross-beam during the pump-and-battery drive can be made with the aid of the equations of unsteady motion of liquid, for the first time obtained by N. Ye. Zhukovskiy and usually called the equations of hydraulic impact. The use of these equations for the solution of the problems about the velocities of the motion of liquid in the conduit/manifold is connected with the cumbersome calculations. Furthermore, for obtaining the specified data it is necessary to know the experimental coefficients of the local resistance which depend on the constructions/designs of the elements of the hydraulic systems, created in connection with this concrete/specific/actual press, and also the character of flow of liquid on the conduits/manifolds. Therefore usually during the calculation of the majority of the hydraulic systems in which occurs the unsteady flow of liquid, are utilized the equations, which do not consider the elasticity of liquid and conduit/manifold (equation of D. Bernoulli for unsteady motion).

But even short-cut calculation of the operating speeds of the motion of the cross-beam of press taking into account to the inertia of its moving elements and to liquid in the conduits/manifolds is frequently hindered/hampered as a result of the complexity of calculating the resistance, exerted by forging during its deformation.

The investigations of the dynamics of powerful/thick hydraulic presses by effort/force 30000 T and above showed that the calculation of the velocities of the motion of cross-beam can be made according to the equations of steady motion with the approximate account of the effect of the elasticity of working fluid and construction/design of press. The presence of storage battery/accumulator in the hydraulic system increases the possibility of the appearance of such harmful hydrodynamic phenomena as the hydraulic impact in the conduits/manifolds and the cavitation of flow in the controls of press. Most effective means against the hydraulic impact is the decrease of the distance between the storage battery/accumulator and the press.

With the large extent of delivery conduit, which connects the bottles of storage battery/accumulator with the press, sharply grow/rise the losses of head to overcoming of fluid friction against the walls of conduit/manifold.

Fig. 37 [32] gives one of the oscillograms, which shows a change in different parameters of press by effort/force 75000 T in the process of working stroke. In this press the bottles of storage battery/accumulator are located at a distance of approximately/exemplarily 10 m from the press.

Utilizing these oscillograms (Fig. 37), it is possible to calculate the total coefficient of resistance of delivery conduit with internal diameter $d_y = 200$ mm which composes 90-100.

The same coefficient for the forcing line of stamping machines by effort/force to 30000 T, when storage batteries/accumulators are located at the considerable distance (40-60 m) from the press, composes 140-280.

From Fig. 37 it is evident that the curves p=f(t) have the separate peaks, which coincide with the moments/torques of switching the steps/stages of effort/force and the being consequence intermittent pressure propagation during valve opening. This is confirmed by the comparison of the curves of the dependence of pressure and valve travel on the time.

Furthermore, even the insignificant manipulation with pressure valve causes noticeable fluctuation of pressure in the cylinder, since the losses of head in the valve are inversely proportional to the square of the area of its flow area.

The elasticity of the elements/cells of press during the determination of the velocity parameters can be determined by the following approximate computation.

The decrease ΔQ of volume Q_0 of working fluid with an increase in the pressure on value Δp comprises

$$\Delta Q = \frac{Q_0}{E_ж} \Delta p, \quad (2)$$

where Q_0 - volume of liquid in the cylinders and the conduits/manifolds between the main distributor and the press, moreover Q_0 changes during the working stroke and can be accepted by constant only in the case of his low value;

$E_ж$ - modulus of elasticity of the water emulsion, generally accepted during the pump-and-battery drive; taking into account to the radial deformation of cylinders and conduits/manifolds

$$E_ж = 2{,}2 \cdot 10^4 \text{ kgf/cm}^2.$$

The deformation of the elements of the construction/design of press in the direction of the motion of cross-beam is composed of the elastic pliability/compliance of columns or struts of frame, plungers, cylinders, cross-beams, upper and lower stamp sets.

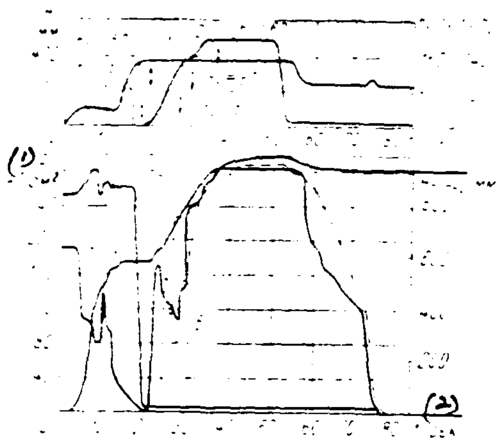

Fig. 37. The experimental curves, obtained during the investigation of the hydraulic system of stamping machine by effort/force 75000 T: 1 - course of the rack of the drive of the distributor of the hoisting and balancing cylinders; 2 - course of the rack of the drive of the distributor of working cylinders; 3 - pressure in the balancing cylinders; 4 - course of cross-beam; 5 - pressure in the working cylinders; 6 - pressure in the hoisting cylinder. Valve travels: h_1 - drain of hoisting cylinders; h_2 - drain of the balancing cylinders; h_3, h_4 - including step/stage of the I effort/force; h_5 - including step/stage II effort/force; h_6 - including step/stage III effort/force.

Key: (1). kgf/cm². (2). s.

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The deformation of columns let us find from the relationship/ratio

$$\delta = \frac{F_p l_k}{E f_k}, \qquad (3)$$

where F_p - area of the plunger of working cylinder (for the multicylinder press the total area of plungers);

l_k and f_k - respectively length and the cross-sectional area of columns.

Deformation of cylinder let us find from the expression

$$\delta_c = \frac{F l_c}{E F_c}, \qquad (4)$$

where l_c, f_c, F_c - respectively the length of cylinder, the cross-sectional area of its walls (total area of the walls of all cylinders for the multicylinder press) and the cross-sectional area of the internal cavity of cylinder (total area of cylinders for the multicylinder press).

The deformation of plungers let us determine from the relationship/ratio

$$\delta_n = \frac{l_n}{L}, \qquad (5)$$

where l_n - length of plunger.

In all resulting expressions E - the modulus of elasticity of steel.

The deformation of cross-beams approximately can be found at the calculation them as the beams/gullies, supported on the edges and loaded either with concentrated forces in the sites of installation of cylinders (upper cross-beam), or by the same forces, and also by the evenly distributed load from the stamp set (the crosshead), or by the same load and by reactions in the bearing edges of columns (base/root of press).

The equation of continuity taking into account to the compressibility of liquid and to the deformation of the elements/cells of press and pipeline can be recorded in the form

$$\left(\frac{Q_0}{E_ж} - \delta F_n\right)\frac{dp}{dt} = v_m f_m \eta_v - v F_n. \quad (6)$$

where δ - total deformation of the elements of the construction/design of press in the direction of the motion of the crosshead;

v_m and f_m - respectively the rate of flow of liquid in the conduit/manifold and the area of its cross section;

η_v - volumetric efficiency of the hydraulic system (for the battery drive we take as equal to 1);

v - velocity of the motion of cross-beam.

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Since $v_1 = \frac{Q_{m}t_{m}}{F_n}$ — the velocity of the motion of the cross-beam of press without the account to the elasticity of liquid and elements of construction/design, and $Q_н = F_n S_н$ ($S_н$ — given idling of press, i.e., considering also the volume of liquid in the conduit/manifold), from equation (6) can be found

$$v = v_1 - \left(\frac{S_н + S}{E_ж} + \delta\right)\frac{dp}{dt}. \qquad (7)$$

After expressing $\frac{dp}{dt} = \frac{dp}{dS}\cdot\frac{dS}{dt} = v\frac{dp}{dS}$, we will obtain

$$v = \frac{v_1}{1 + \left(\frac{S_н + S}{E_ж} + \delta\right)\frac{dp}{dS}}. \qquad (8)$$

The equation of forward motion of cross-beam without the account to the inertness of moving elements, and also action of balancing and return cylinders can be recorded in the form

$$pF_n\left(1 - \frac{K}{D_n}\right) - G - P_D(S) = 0, \qquad (9)$$

where

K - coefficient of the friction of plunger against the sealings/packings/compactions (with the work on water emulsion accept K=0.7-0.8 [1]);

FOOTNOTE [1]. V. p. Linz. Experimental study of sealings/packings/compactions of the hydraulic cylinders of powerful/thick presses. TsBNTI [ЦБНТИ - Central Office of Scientific and Technical Information] of TsNIITMASh, [Central Scientific Research Institute of Heavy Machinery] 1958. ENDFOOTNOTE.

D_n — diameter of the plunger of cylinder;

G - mass of moving elements;

$P_D(S)$ — resistance to deformation of blank.

Hence let us determine pressure:

$$p = \frac{P_D(S)}{F_n\left(1-\frac{K}{D_n}\right)} - \frac{G}{F_n\left(1-\frac{K}{D_n}\right)} \qquad (10)$$

or

$$\frac{dp}{dS} = \frac{1}{F_n\left(1-\frac{K}{D_n}\right)} \cdot \frac{dP_D}{dS}. \qquad (11)$$

After substituting formula (11) into expression (8), we will obtain

$$v = \frac{v_1}{1 - \left(\frac{S_n - S}{E_n} - \delta\right)\frac{1}{F_n\left(1-\frac{K}{D_n}\right)} \cdot \frac{dP_D}{dS}}. \qquad (12)$$

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Let us designate

$$\varepsilon = \frac{1}{F_n\left(1-\frac{K}{D_n}\right)}\left(\frac{S_n - S}{E_n} - \delta\right).$$

then

$$v = \frac{v_1}{1 - \varepsilon\frac{dP_D}{dS}} \qquad (13)$$

Express v_1 depending on efforts/forces and parameters of conduit/manifold, for which we will use the equation of Bernoulli, written for delivery conduit with the velocity transformation of liquid in it to the velocity of working transfer plunger;

$$\frac{p_a}{\gamma} = \frac{v_1^2}{2g} D_n^4 \left[\sum_{i=1}^{n} \frac{\xi_i}{d_i^4} + \sum_{i=1}^{n} \lambda_i \frac{l_i}{d_i^5} \right]. \qquad (14)$$

where ξ_i – total coefficient of the local resistance of the i section of conduit/manifold;

l_i, d_i – respectively length and the diameter of the i section of conduit/manifold.

Hence, designating

$$P_a = p_a F_n \left(1 - \frac{k}{D_n}\right) - G,$$

$$A = \frac{\gamma}{2g} D_n^4 F_n \left(1 - \frac{k}{D_n}\right) \left(\sum_{i=1}^{n} \frac{\xi_i}{d_i^4} + \sum_{i=1}^{n} \lambda_i \frac{l_i}{d_i^5} \right).$$

let us find

$$v_1 = \sqrt{\frac{P_a - P_D(S)}{A}}. \qquad (15)$$

Then the resultant expression of the velocity of the crosshead taking into account to the compressibility of liquid and to the pliability/compliance of the construction/design of press takes the form

$$v = \frac{1}{1 - \varepsilon \frac{dP_D}{dS}} \sqrt{\frac{P_a - P_D(S)}{A}}. \qquad (16)$$

The experiments, carried out in VNIIMETMASh, show that as a result of the elasticity of the system of press the velocity of the motion of cross-beam in the dependence on the character of growth of pressure in the cylinders can increase or be decreased by 100o/o and more [32].

The characteristic features of the hydraulic systems of powerful/thick presses are the following. Provision is made for several steps/stages of the efforts/forces, developed with press, which creates favorable conditions for its most economical operation.

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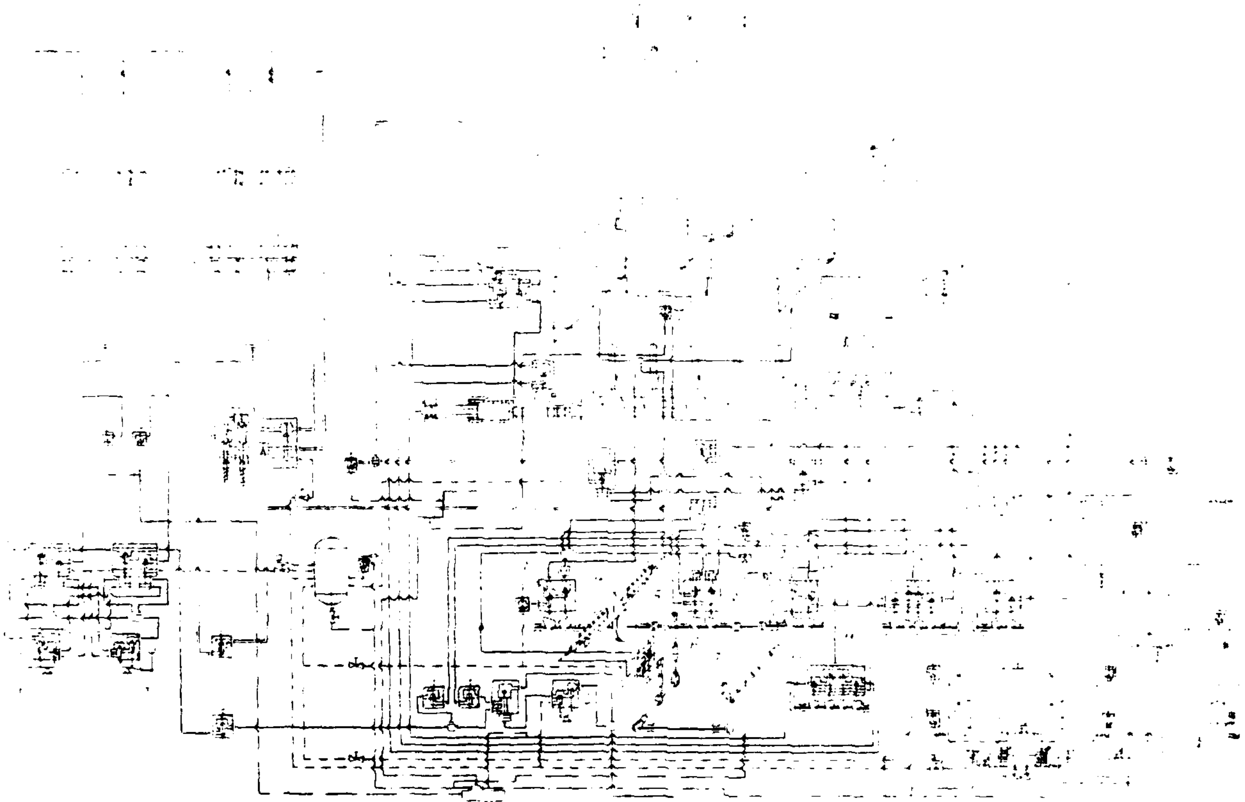

Fig. 38. Schematic hydraulic diagram of press UZTM with effort/force 30000 T: 1, 2 - electromagnetic distributors of control of multipliers; 3 - distributor of control of hoisting cylinders; 4 - hydraulic motor; 5 - camshaft; 6 - two-valve distributor of control of hydraulic motor; 7 - terminal switch; 8 - distributor of control of working cylinders; 9 - basic lever; 10 - distributor of control of balancing cylinders; 11 - distributor of control of central knockout; 12 - distributor of control of cylinders of movement of table; 13 -

distributor of control of side knockout. Designations: — main line with the pressure 450 kgf/cm²; ——— main line with the pressure 320 kgf/cm²; - - - - - drain line; drain line; - - air duct.

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For warning/preventing the possible breakage of flow, which enters the working cylinders in the beginning of the motion of cross-beam, are established/installed the balancing cylinders. Unloading these cylinders at the end of the idling of cross-beam gives first stage of force, developed with press, without the connection of working cylinders to the storage battery/accumulator.

The pump-and-battery station of press by effort/force 75000 T is made two-section: pressure in first section 200, in second 320 kgf/cm². The second step/stage of effort/force in this press is created by the connection of all working cylinders to the storage battery/accumulator by pressure 200 kgf/cm². By the subsequent connection to the storage battery/accumulator by pressure 320 kgf/cm² first by one, and then another group of working cylinders are created the two additional steps/stages of effort/force. The use/application of two pressures in the pump-and-battery station provides the uniform loading of press at the second step/stage of the developed effort/force. At this step/stage of presses usually works the greatest time, also, with the maximum velocities of motion.

Furthermore, because of the application of two pressures the large part of the time of presses it works with the reduced (in comparison with when is applied one pressure) pressure differential between the storage battery/accumulator and the working cylinders, which raises durability of the parts of the devices of control (valves, saddles, etc.).

Together with the use of a two-section pump-and-battery station for the drive of powerful/thick stamping machines is applied the storage battery/accumulator in combination with hydraulic multiplier. This drive is used in the press by the effort/force 30000 T UZTM whose schematic hydraulic diagram is shown in Fig. 38. The pressure 320 kgf/cm², created in the storage battery/accumulator, is raised by multiplier to 450 kgf/cm². With respect to these pressures of presses it develops efforts/forces 20000 and 30000 T.

For the decrease of losses of head to fluid friction against the walls of conduit/manifold and exception/elimination of the possibility of appearance in the conduit/manifold of the hydraulic impacts of large force the bottles of the pump-and-battery station in the majority of powerful/thick press installations/settings up are carried out of the location pumping, placed at the considerable distance from the press, and they are established/installed directly in press after the control panel (Fig. 39).

In the presses with the increased operating pressure (more than 320 kgf/cm²) the use/application of a multiplier is caused by the absence of battery stations to the pressure of more than 320 kgf/cm².

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The constructions/designs of multipliers in the pressure 1000 kgf/cm², used for the drive of small presses by effort/force 15000 and 30000 T, make it possible to create two steps/stages of effort/force at pressure by 600 and 1000 kgf/cm². Such multipliers (Fig. 40) are excessively bulky. Their weight reaches 65o/o of weight of press. Are designed the lightened hydraulic multipliers on the basis of the constructions/designs, fastened by winding of the high-strength tape. The exemplary/approximate overall dimensions of press with effort/force 30000 T with this multiplier are visible from Fig. 28b.

Experience of operating hydraulic presses showed the need for control over a wide range of the effort/force, developed with press. This is caused, first of all, by the fact that the additional loading of die/stamp after shaping of the die-forged forging leads to the increased elastic bearing strains of the working surfaces of die/stamp and die base-plates. As a result sharply increases an error in the size/dimension of part in the height/altitude.

To the greatest degree this negative phenomenon is manifested during stamping of the thin finned articles made of the light alloys with the large sizes/dimensions in the plan/layout. Overloading on the die/stamp leads to a reduction/descent in its durability. The working surface of die/stamp undergoes plastic deformation, which also decreases the precision/accuracy of stamping. The stepped control of effort/force in many instances does not satisfy technological requirements. Furthermore, it has other shortcomings.

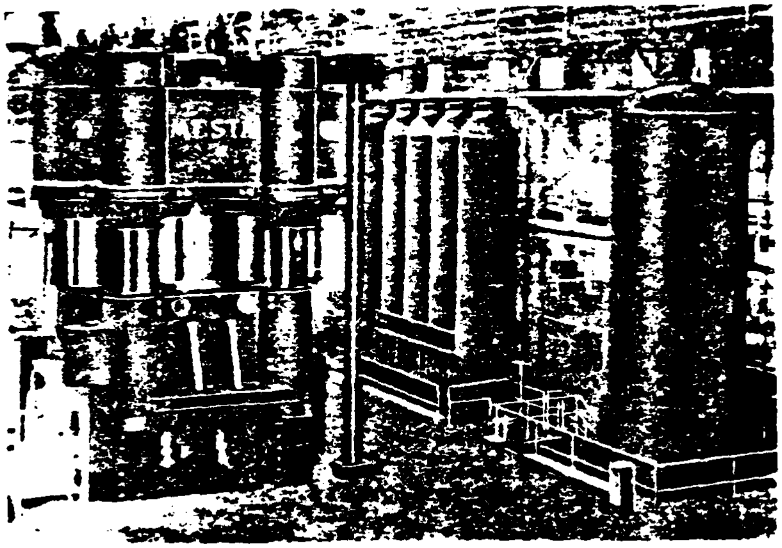

Fig. 39. The arrangement of battery bottles is direct about the press (press 16200 T of the firm of place) [29].

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Thus, usually for obtaining the steps/stages of the effort/force, developed with press, it is necessary to connect one or the other number of cylinders. In this case frequently are created the adverse conditions of loading of its construction/design, which causes the nonuniform wear of the parts of cylinders. In the case of feeding from the storage batteries/accumulators with the different pressures becomes complicated control system by press. Is virtually inexpedient the creation of the stations, which have more than two - three sections with different pressure. The use of multipliers also does not provide obtaining many steps/stages, it complicates the system of drive and control of press and is decreased its rapidity.

Most modern is the infinitely variable control of the effort/force of press due to the decrease of pressure in the storage battery/accumulator the expansion of air (by bleeding from the specially provided for in the bottles storage battery/accumulator of regulating volume).

In this case for the feeding of the cylinders of recurrent course and cylinders of auxiliary mechanisms necessary is the separate small accumulator of constant pressure. Storage battery/accumulator with the adjustable pressure makes it possible to obtain in practice any forces of press and, as a rule, raises efficiency of press installation/setting up, and an included in this case into the pump-and-battery station regulating volume of liquid can be utilized for an increase in the working stroke of stamping machine.

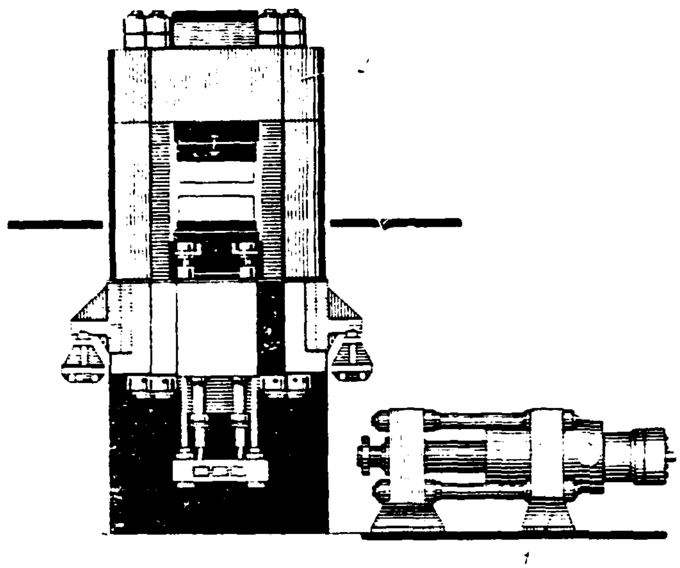

Fig. 40. Hydraulic multiplier (1), which develops pressure 1000 kgf/cm² and utilized in the drive of press 2 with effort/force 30000 T.

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However, the presence of the regulating volume of liquid leads to the considerable increase of the volume of storage battery/accumulator, which increases with the expansion of the range of the control (with the range 160-320 kgf/cm² the volume of the common adjustable storage battery/accumulator increases almost 2 times in comparison with nonadjustable).

In VNIIMETMASh [1] is develcped the diagram of the pump-and-battery station, which makes it possible tc ensure the sufficiently broad band cf pressures with the minimum regulating vclume of liquid [39].

FOOTNOTE [1]. B. V. Rozancv, L. D. Gcl'man et al. Pump-and-battery station. Author's certificate Nc 180486. Bulletin of inventicns, 1966, No 7. ENDFOOTNOTE.

The common adjustable storage battery/accumulator at maximum pressure p_{max} contains the volume cf air $Q_{в}$ ensuring the permissible pressure drop in the storage battery/accumulatcr (10-15o/o of initial pressure) with the expenditure/consumption frcm it during the working strcke of the maneuvering vclume cf liquid $Q_{м}$. But if we before the translaticn/conversion cf staticn into the lower pressure disconnect the part cf air volume $\Delta Q_{в}$ the necessary pressure can be cbtained by the drain of the smaller regulating vclume of liquid $Q_{р}$ in comparison with the contrcl withcut the cutoff/disconnection of air, after which it is necessary tc restcre in the storage battery/accumulator air vclume $Q_{в}$ ($Q_{ов} \geq \Delta Q_{в}$). In this case the incidence/drcp pressure fcr the wcrking stroke will nct exceed 10-15o/c.

We accept, that the pressure is regulated iscthermally, and the expansion of air in the process of working stroke occurs polytropically with the polytropic exponent n=1.3-1.4, a pressure drop in this case comprises not more than 10o/o initial pressure p_{max}. Then for the storage battery/accumulator, adjusted without the cutoff/disconnection of air volume, we have

$$p_{max}Q_{e} = p(Q_{e} - Q_{pez}); \quad (17)$$

$$p_{max}Q_{e}^{n} = 0{,}9p_{max}(Q_{e} + Q_{ж})^{n}. \quad (18)$$

By analogy for the storage battery/accumulator, adjusted with the preliminary cutoff/disconnection of the part of air volume ΔQ_{e}, we obtain

$$p_{max}(Q_{e} - \Delta Q_{e}) = p(Q_{e} - \Delta Q_{e} + Q'_{pez}); \quad (19)$$

$$p_{min}(Q_{e} - \Delta Q_{e} + Q_{pez})^{n} = 0{,}9p_{min}(Q_{e} - \Delta Q_{e} - Q'_{pez} + Q_{ж})^{n}. \quad (20)$$

It is obvious that with the given volume of liquid $Q_{ж}$ [volume of air Q_{e} we determine from the expression (18)] the condition, recorded by equation (19), it is observed only when $\Delta Q_{e} = Q'_{pez}$.

After the transformations of expressions (17)-(20) we obtain

$$Q'_{pez} = Q_{pez}\frac{p}{p_{max}}. \quad (21)$$

from which it is clear that the savings of regulating volume are greater, the wider the range of control, and when $\frac{p_{max}}{p} = 2$ it reaches 50o/o.

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In practice a control on the described diagram can be carried out, after distributing air volume Q_c in the larger possible number of bottles of small amount of capacitance. In this case the disconnected volume of air will be multiple the capacity/capacitance of the utilized compressed air tanks, which provides the approximate observance record conditions by expressions (20) and (21).

Satisfactory result is achieved by air distribution in four - six bottles (pressure drop for the working stroke in the range $p_{max}-p_{min}$ it comprises 8–13%). Taking into account that in the common storage batteries/accumulators the air volume is dispersed on several bottles (maximum capacity/capacitance of the produced by industry bottles does not exceed 10 m³), the creation of the pump-and-battery station on the described diagram does not cause special difficulties.

Fig. 41 shows the diagram of the pump-and-battery station with the infinitely variable control of the pressure of powerful/thick multicylinder stamping machine. Let us compare the technological possibilities of press by effort/force 75000 T during the use/application of this station and station of two sections with pressures by 200 and 320 kgf/cm². Two pressures of the pump-and-battery station provide three steps/stages of the effort/force: maximum and efforts/forces, which compose 60 and 80o/o of maximum. In the case of using the diagram, shown in Fig. 41, it is possible without an increase in th existing number of bottles to steplessly regulate the effort/force of press from 40 to 100o/o of maximum.

Furthermore, appears the possibility of an increase in the working stroke due to the use of the remaining part of the adjusted volume. In other words, a part of the bottles, in which is placed regulating volume, can be utilized as the maneuvering ones.

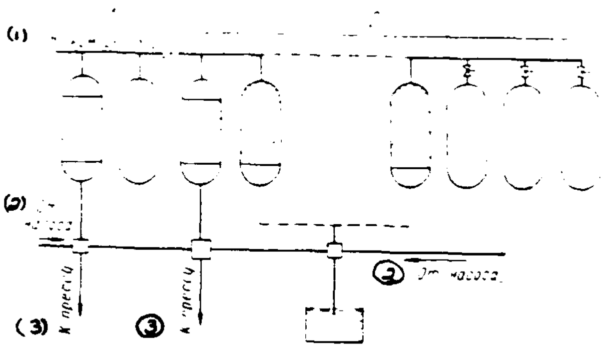

Fig. 41. Diagram of pump-and-battery station with the infinitely variable control of the pressure: 1 - the section of constant and 2 - the section of adjustable pressure [39].

Key: (1). From compressor. (2). From pump. (3). To press.

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An increase in the working stroke must be matched with a change in the air volume. Otherwise the very possible large pressure drop at the end of the working stroke. An increase in the latter is limited to the remainder/residue of liquid after the drain of the part of the regulating volume.

If we designate remaining after disconnection i of compressed air tanks and drain ΔQ the air volume through Q_k, than we will obtain the following relationship/ratio of pressures in the beginning

(p_n) and end (p_k) of the working stroke:

$$\frac{p_k}{p_n} = \left(\frac{Q_n}{Q_n + Q_m}\right)^{1.3}. \qquad (22)$$

Hence maximally possible maneuvering volume for data $\frac{p_k}{p_n}$ we find from the expression

$$Q_{m\,max} = Q_n\left[\left(\frac{p_n}{p_k}\right)^{1/1.3} - 1\right]. \qquad (23)$$

So $Q_{m\,max} = 0.13\,Q_n$ for $\frac{p_k}{p_n} = 0{,}85$ and $Q_{m\,max} = 0{,}086\,Q_n$ for $\frac{p_k}{p_n} = 0{,}9$.

The calculations of the value of maximum working course under the assumption of a pressure drop for the course not more than 15o/o initial show that at a pressure 200 kgf/cm² and the presence of the pump-and-battery station with the adjustable pressure the working stroke can be increased to 400 mm, i.e., almost 2 times in comparison with the fact that gives use/application of a common pump-and-battery station.

At a maximum pressure 320 kgf/cm² working stroke can be increased to 530 mm due to the connection to the working cylinders of the section of pumping-battery station with the constant pressure, which feeds auxiliary mechanisms. Maximum working course at the prescribed/assigned pressure (part of compressed air tanks is opened in order to attain the maximum effectiveness of control with a minimum quantity of bottles) is depicted in Fig. 42. The bottles, utilized for pressure adjustment and for completing/adding the maneuvering volume, must be equipped by the distributor which makes it possible if necessary to feed liquid to the press or to throw off it into the tank. The bottles, utilized only for the control, must have a branch/removal into the drain line; moreover before this line is installed the choke/throttle, which makes it possible to depressurize with the control.

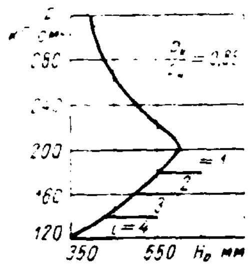

Fig. 42. The value of possible working stroke of press depending on the pressure of liquid accepted in the pump-and-battery station from the regulator station with the adjustable pressure: $p_н$ and $p_к$ - respectively the pressure of liquid in the beginning and end of the working stroke; i - number of disconnected compressed air tanks.

Key: (1). kgf/cm².

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For the control of presses are applied the servo systems, which ensure the dependent on the control handles discovery/opening of forcing and drain valves. In this case for ease of control entire equipment to more expediently place it is lower than the level of the floor (under the plate flooring), and to the control panel to carry only the levers, connected with the support systems of control. Control of these levers does not require the application of large force.

For warning/preventing the possible emergencies during the disturbance/breakdown by operator the control sequences of different mechanisms of press provide for the appropriate interlocking devices, while for warning/preventing the sharp stop of cross-beam in its end positions and excessive dropping of cross-beam in the absence of the set of plates/slabs in the under-stamping block - valves with their automatic operation from terminal switches.

The use/application of storage batteries with the adjustable pressure makes it possible to work with minimum pressure differentials between the storage battery/accumulator and the working cylinders. This decreases the erosion of elements/cells in the control devices due to abrasion and cavitations. As far as cavitation is concerned, the physical nature of this phenomenon and called by it erosion is very complicated and up to now completely opened. The creation of the modes/conditions during which the cavitation in this hydraulic apparatus can be brought to the minimum, presents great difficulties.

For increasing durability of the parts of valves, which work under severe conditions, by TsNIITMASh were carried out the analyses of cavitation durability of materials on the magnetostrictive instrument, and also on the specially created installation/setting up for the percussive effect of flow on the samples/specimens [1].

FOOTNOTE [1]. Work on the study of durability of materials on magnetostrictive instrument and the selection of materials for the valves of saddles is carried out under the management of G. N. Babushkina and M. G. Timmerbulatova. ENDFOOTNOTE.

The works conducted made possible to select most stable materials for the parts of valves and to develop the mode/conditions of their treatment. the most adequate/approaching materials for manufacturing the parts of valves are tool steel ShKh15.9Kh and high-chromium 4Kh9S2.3Kh13.

3. Gauging and monitoring-measuring equipment.

Besides the common equipment, used in the forging-and-pressing equipment, for the control of the technological process of stamping, and also for guaranteeing of reliability and service life of such single-design machines as powerful/thick presses, were created special instruments.

Some technological processes, accomplished on the stamping hydraulic machines, require the control of the velocity of working strcke according to the specific program.

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For example, with the urdeviating press forging by the effort/force 31500 T of firm Levi the recessary quality of article is guaranteed by certain optimum velocity which can change during the working strcke in the dependence on the filling with the metal of the cavity of die [51].

Velocity changes occur on the stroke of press upon reaching by the crosshead of the specific, previously selected positions.

Forward motion of cross-beam is converted into rotary motion of the shaft of the so-called electromechanical code converter from which are removed/taken the signals of direct current, the fixing position cross-beams. The structural diagram of control system is shown in Fig. 43. The signals of direct current during closing/shorting of the corresponding contacts of converter enter the unit of the start of control relay. The switches of unit are adjusted to such position of cross-beam in which should be changed the velocity.

With the agreement of the signals of the position of cross-beam with the adjustment of switches by the cut-in relay of control which will lock potentiometer circuit of the control of velocity. The latter is established/installed in such a way that the removed from it stress/voltage would coincide with the stress/voltage of the tachogenerator, which measures the actual velocity of cross-beam, if this velocity achieved necessary value. If velocity differs from necessary, then appearing voltage difference of potentiometer and tachogenerator actuates the electromagnet of the relay valve of the hydraulic motor of the choke/throttle, which gauges fluid flow into the working pressure cylinders.

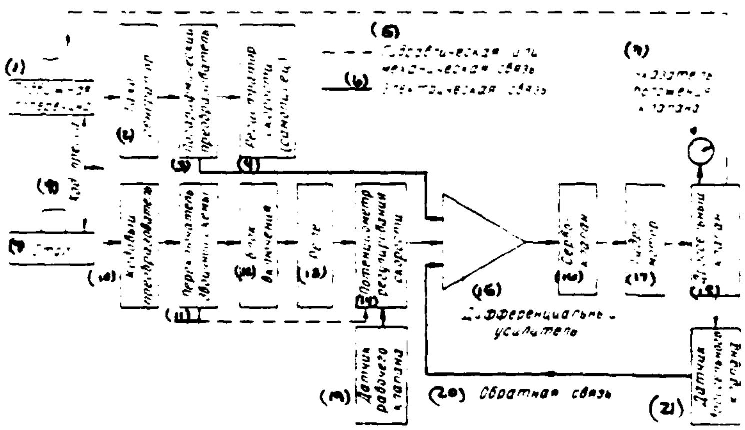

Fig. 43. Structural diagram of the automatic control system of the velocity of the working stroke of press by the effort/force 31500 T of firm Levi [51].

Key: (1). Movable cross-beam. (2). Tachogenerator. (3). Logarithmic converter.) (4). Monitor of velocity (chart recorder). (5). Hydraulic or mechanical connection/communication. (6). Electric coupling. (7). Position indicator of valve. (8). Stroke of press. (9). Table. (10). Code converter. (11). Switch of binary diagram. (12). Unit of inclusion/connection. (13). Relays. (14). Potentiometer of control of velocity. (15). Differential amplifier. (16). Relay valve. (17). Hydraulic motor. (18). Throttle valve. (19). Sensor of working valve. (20). Feedback. (21). Sensor of throttle valve.

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Throttle valve is moved until is established/installed necessary velocity. After this the corresponding stresses/voltages are aligned and throttle valve is disconnected.

System can be adjusted to four different positions of cross-beam, in each of which is provided necessary velocity (Fig. 44).

Press by effort/force 31500 T is equipped by relief valve, which depressurizes in the working cylinders upon reaching of the prescribed/assigned force. This valve is provided for in order to avoid a breakage in the die/stamp in the case of stamping with the increased specific forces. The unloading indicated can be connected with the control of velocity, but it can be realized and independent of this.

The powerful/thick hydraulic stamping machines, which have complicated large-size assemblies and parts, work under the severe conditions of loading. For warning/preventing the possible breakages in the parts it is necessary in the process of the work of press to check stresses/voltages in the most loaded parts and to in proper time remove the reasons, which call their overstress.

For the control/check indicated is developed the equipment, which equipped powerful/thick stamping machines [17]. This equipment provides the continuous automatic measurement of stresses/voltages in the parts of press with the supply of command impulse on the cutoff/disconnection of drive with the emergence of dangerous stresses/voltages. Equipment also supplies light signaling with the overloading of press and records the number of stresses/voltages, which exceed those permitted, in each of the controlled/inspected points.

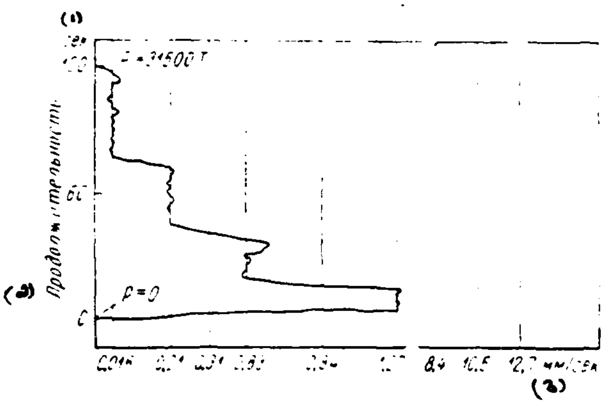

Fig. 44. Indicator diagram, which characterizes a change in the velocity of the crosshead of press by the effort/force 31500 T of firm Levi in course [51].

Key: (1). s. (2). Duration. (3). mm/s.

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On the stresses/voltages in the parts of press it is possible to check the actual center-of-pressure location on the die/stamp, which is especially important during stamping of the unsymmetric finned panels and other parts, for which to calculate center of pressure is difficult. Die setting on the center of pressure makes it possible to obtain the articles of a good quality and provides uniform load distribution on the elements/cells of press.

The action of equipment is based on the measurement of elastic deformations of the parts of press by special synchrotransmitters.

The kinematic diagram of instrument is shown in Fig. 45.

Synchrotransmitter 1 (type BD-404A) with the aid of the special reducer, which consists of parts 2-5 and which converts linear displacements into the angular ones, records the deformations of the controlled/inspected part which are absorbed by measuring tip 6.

Receiving synchro 7 (type BS-404A) is installed in the special measuring channel and connect by guide with the synchrotransmitter. In the same channel are located the remaining elements of the signaling system: executive electromagnetic relay, counter of overloadings and trip relay.

On the axis/axle of receiving synchro is attached arrow/pointer 8, which indicates scale 9 on the known scale of the deformation of the controlled/inspected part. Simultaneously arrow/pointer 8 turns arrow/pointer 10, which is attached on the front/leading panel of the unit of receiving synchro and makes it possible to fix/record the breaking stresses, which occur during the specific period (replacement, days, etc.).

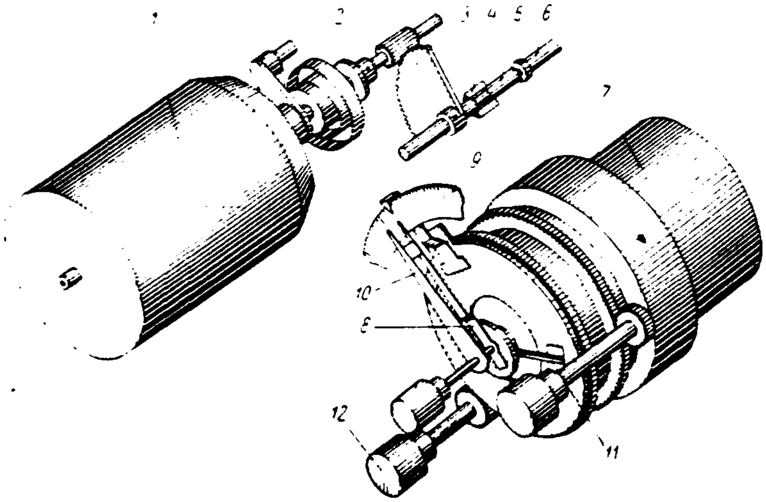

Fig. 45. Synchrotransmitter and receiving synchro [17].

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Indicator has a signaling system which is switched on upon reaching in the controlled/inspected part of dangerous deformations.

The feed circuit of the electromagnetic relay of the signaling system is closed with the contact of contacts 11. These contacts are fastened on the ring and are installed in the space required the scales with the aid of knob/stick 12, derived to the front/leading panel of unit. During the closing of contacts operates/wears the executive electromagnetic relay, which controls the ignition of indicator lamp, by the start of the counter of overloadings and powerful/thick trip relay.

Since the axle weight of receiving synchro is low, displacement angle of its with the synchrotransmitter does not exceed 0.5°, which provides the necessary accuracy of measurement.

Fig. 46 shows synchrotransmitter with locations. In the lower cover/cap of sensor 1 is screwed in strut 2, into which is leaned the leg of an indicator of 3 dial-types. The housing of indicator is attached on thrust by 4, moving during the deformations of the controlled/inspected part of press. Consequently, indicator is the indicator of the mechanical extensometer, with the aid of which are accomplished/realized the control/check and the calibration of equipment.

Indicator is equipped with the telltale fixing counter, attached on the glass. Arrow/pointer is balanced and turned due to the application of small force. With the increase of deformation the fixing arrow/pointer moves together with the basic arrow/pointer of indicator, making it possible to record the greatest deformations (stress/voltage) for one or another time interval (replacement, days, etc.). Testing showed that the required for the displacement of telltale counter small force does not introduce additional errors into readings/indications of indicator. The measurement of deformations is made in the section, equal to 400 mm. In this case absolute deformation of the controlled/inspected part with the stress/voltage 200 kgf/cm^2 is 0.4 mm.

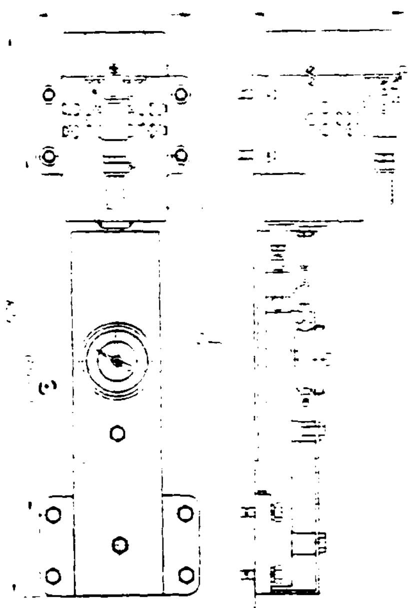

Fig. 46. Synchrotransmitter with locations [17].

Key: (1). base.

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Equipment makes it possible to reliably measure deformations on the order of 0.01 mm; thus, stresses/voltages are measured with an accuracy to 50 kgf/cm². For guaranteeing this precision/accuracy it is necessary to eliminate the effect of thermal deformations. This is achieved by the periodic correction of the zero position of the arrows/pointers of the indicator of measuring channels at the loaded press.

The installation/setting up of equipment on the presses is very effective, it facilitates their operation, by it must be equipped all stamping hydraulic machines by the effort/force of more than 5000 T.

For the checking of stresses/voltages in the columns of powerful/thick press can be used the equipment, developed by Novosibirsk plant "Tyazhstankogidropress" im. A. I. Yefremov for the press by effort/force 30000 T [2].

In order to describe efficiency of one or the other parts of presses for the purpose of the development of the optimum conditions for their operation and gliding the repairs, it is necessary to know not only a quantity of loadings, which exceed those permitted, but also a quantity of loadings with different efforts/forces for the specific time intervals. This information is necessary also for accomplishing the calculations to the fatigue strength of parts. Even such parts of press as upper cross-beam, base/root, crosshead, testing/experiencing with the loading relatively low averaged voltages, get out of order due to the insufficient fatigue strength, which is explained by the effect of different stress concentrators (holes, apertures, etc.).

For obtaining information indicated was created the automatic instrument-counter SNP, the principle of work of which consists in the transformation of the pressure impulse of liquid in the line of working pressure cylinders into the electrical signal, fixed/recorded by electromagnetic counter. The transformation indicated is accomplished/realized by the electric-contact manometer, which has two pairs of contacts. One manometer makes it possible to fix/record the value of two pressures.

With instruments SNP are equipped stamping machines with effort/force 75000, 30000 and 15000 T, and also forging presses with effort/force 6000 T, horizontal-staged presses with effort/force 12000 and 20000 T, etc., established/installed in the same shops, as stamping. Instrument records a quantity of loadings with each step/stage of effort/force. At the same time any possible fluctuations of pressure in the working cylinder do not affect the results of reading. Let us explain the electrical circuit of instrument, shown in Fig. 47.

By the variable stress 110 c, obtained through the step-down transformer, feeds relay circuit RU, RP-0, RN-1, RN-2, RP-1-RP-4.

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The stress/voltage 48c, obtained through the step-down transformer, is converted by rectifier on the semiconductor diodes into constant stress, battery supply relay FV, FES (relay of operation), the electric-pulse counters M-1-M-4, and also the delay line of the operation of relay RES and timer FV.

In the initial position (pressure in the hydraulic system of press is absent) normally closed contacts EKM-1 and EKM-2 are closed, and relay RN-1 and RN-2 are prepared to the inclusion/connection. With the application of voltage of relay RN-1 and RN-2 they operate/wear. Their normally extended contacts in the relay circuit RU and RP-0 are closed, which leads to the operation of relay. In this case are closed the normally open contacts of relay RU and RP-0, preparing relay circuit RP-1-RP-4 for inclusion/connection. The coil of relay RU is blocked by normally open contact. Thus, RU is established/installed to self-supply.

Let us assume that normally the closed and normally open contacts EKM-1 of manometers are established/installed to the pressures 100 kgf/cm² and 200 kgf/cm². When line pressure, with which are connected the manometers, achieves 100 kgf/cm², normally closed contact EKM will be disconnected, after disconnecting relay RN. As a result will be included/connected by relay RP-1, will be locked normally open contact RP-1 in the circuit of counter M-1. The magnet cf counter M-1 will attract armature.

If pressure in the hydraulic system of press falls tc 0, normally closed contact EKM will be locked, will cperate/actuate relay RN-1. In accordance with this normally closed contact RN-1 in circuit RP-1 will be disconnected and will disconnect RP-1. will occur breaking normally cpen contact RP-1 in the circuit cf counter M-1. The coil of counter will be de-energized, its magnetic system will operate/actuate, and will occur the reading of loading.

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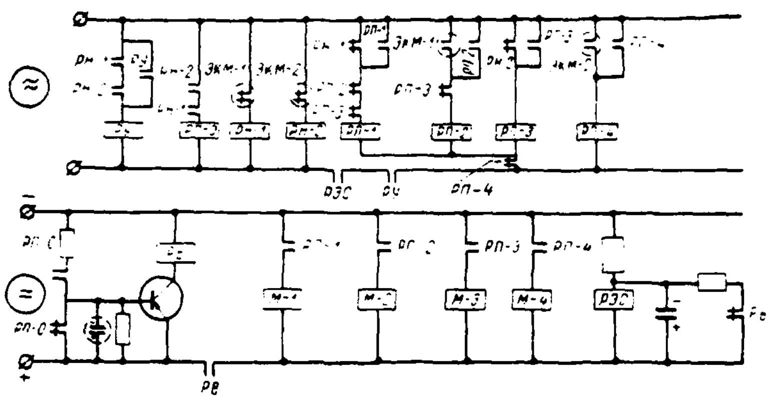

Fig. 47. Electrical counter circuit of the loadings of hydraulic press.

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So that there would not occur the reading at the moment of the random fluctuation of pressure in the process of loading and during switching of relay, into the circuit is connected the timer RV, and also the delay circuit.

On reaching/achievement of pressure 200 kgf/cm² will be locked the normally open contact EKM, switching on the appropriate relays and counter M-2.

The contacts of manometer EKM-2 can be established/installed, for example, to pressures by 300 and 400 kgf/cm². In this case the instrument works just as at pressures by 100 and 200 kgf/cm².

Into the assembly of counter SNP enter the unit of counters and the unit of manometers. To the front/leading panel of the unit of counters are derived electromagnetic counters, and also toggle switch of inclusion/connection, the indicator light and safety device/fuse. On the internal panels are established/installed the remaining network elements.

The feeding of electrical circuit is accomplished/realized from the net of alternating current by a voltage 220c. The prolonged operation of instruments (since 1961) came to light/detected/exposed their high reliability and complete stability of readings/indications.

The described equipment is stationary and is applied in the process of equipment maintenance.

For the study of powerful/thick presses are utilized widely known instruments of the general purpose and specially developed equipment.

During the investigation of stresses and strains in the most important elements/cells of press are applied wire and mechanical extensometers, carbon dynamometers, etc.

Investigations of the dynamics of the drive of press give the possibility to come to light/detect/expose energy and dynamic characteristics during the different operating modes in the function of time. Obtained information make it possible to quantitatively and qualitatively characterize different periods of operating cycle, and they also serve as auxiliary material during the calculation of drive during the design of presses.

The basic determined values are the velocities of the motion of the operating unit of press, the time of separate courses and cycle as a whole, duration and character of the operation of the controls, fluctuation of pressure in the hydraulic system, etc. The parameters being investigated are written/recorded usually on the loop oscillographs, and pressures are measured with the aid of the capacitive diaphragm sensors and tubular type sensors with the resistance strain gauges.

Tubular type sensor for measuring the pressures, which are 100-450 kgf/cm², has the cylindrical housing which is made one whole with coupling; the latter is screwed in into the conduit/manifold. To the housing is stuck the resistance strain gauge, shielded by the cap/hood which is slipped over branch. Wires/conductors are derived through the hole in the cap/hood.

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Sometimes for the complete development/detection of the dynamics of the work of press is necessary the recording of the high (320 kgf/cm²) and low (10 kgf/cm²) pressures of liquid at one and the same point of hydraulic system. Can arise need in the recording of high pressure and vacuum. For this purpose are designed two different sensors, one of which is equally sensitive to the high and low pressures, and the other - to the high pressure and the vacuum. The device of these sensors is almost analogous (Fig. 48) [5].

In housing 1 is established/installed the membrane/diaphragm 2 whose thickness for the sensor "high pressure - vacuum" about 0.5 mm, and for the sensor "high - low pressure" 1.2 mm. In bushing 3, which presses the membrane/diaphragm, is screwed in sleeve/beaker 4, on the surface of bottom of which they stick resistance strain gauge 5. The latter fixes/records high-pressure changes. Between membrane/diaphragm and bottom of sleeve/beaker gapped, sufficient, so that with the excess of calculated low pressure the membrane/diaphragm would be leaned into the bottom of sleeve/beaker. The membrane/diaphragm 2 through pin 6 is connected with diaphragm 7, forced against face of bushing 3 by cover/cap 8. The diaphragm, to which is stuck resistance strain gauge 9, repeats the deformation of the membrane/diaphragm. As a result the extensometer fixes/records low pressure or vacuum.

The displacements of the moving elements of the presses fix/record string hodographs. Hodograph (Fig. 49) is found in housing 3 of sheet aluminum which is fastened to the press with clamps 4. Within the housing are placed busbars/tires 8 and guide of 5 sliders 6 with textolite crosshead 7. Motion to the slider is transmitted through string 1, connected with the moving/driving organ/control (for example, with the crosshead). Two spring-loaded slide contacts slip together with the crosshead on the busbars/tires. Hodograph is switched on in the electrical circuit through the three-conjugate joint. Special hodographs utilize for measuring the misalignments of the crosshead. Their device is described in chapter VI.

During the use of hodographs the velocities of the motion of the crosshead, valves and other moving elements/cells determine by the graphic differentiation of the recording of displacements.

Although the use/application of an oscillograph provides the possibility of the recording of the studied parameters, which are changed during the short time however it is connected with the use of special personnel and the expenditure of relatively long time for the treatment of experimental material.

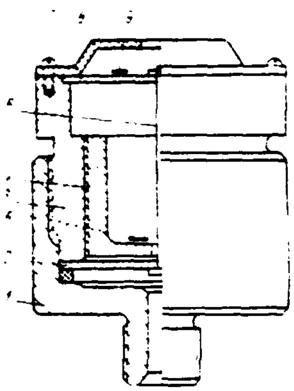

Fig. 48. Two-stage pressure sensor [5].

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In the majority of the cases in the hydropresses the parameters change during the relatively long time. Based on this by VNIIMETMASh it is created instrument for the simultaneous recording of pressure in the hydraulic system, the velocity of working stroke and temperature of blank or instrument [21].

The structural diagram of instrument is shown in Fig. 50.

The basis of recording unit is the produced by Soviet industry high speed recording three-channel instrument H320-3. Frequency of its natural vibrations is 5 Hz, the current of the full deflection of 16 mA. The recording element/cell is made in the form of capillary tubular arrow/pointer.

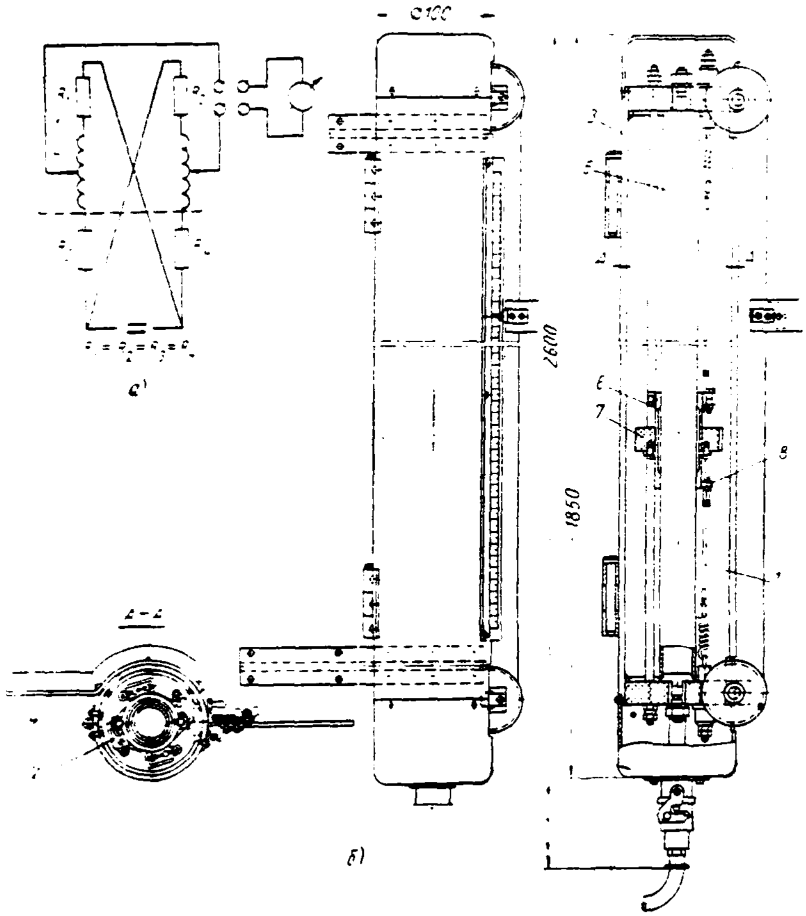

Fig. 49. Hodograph for the recording of the displacements of the moving elements: a) schematic diagram; b) construction/design; 1 - string; 2 - slide contact; 3 - housing; 4 - clamp; 5 - being guided; 6 - slider; 7 - traverse; 8 - bustar/tire.

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The precision/accuracy of recording is estimated with an abrupt change in the fixed/recorded parameter by the value of the so-called change-over

$$S = \frac{a_1 - a_0}{a_0} 100\%,$$

where α_1 - throw of pointer in the beginning of its oscillations with a sudden change in the fixed/recorded parameter;

α_0 - drift of arrow/pointer.

Amount of change-over does not exceed 2-4o/o. It is regulated by the change external resisting, to which is closed measuring winding of instrument. For developing/scanning the written/recorded processes on the time and method the synchronous motor, generally accepted in
ShDR
instrument H320-3, is replaced by step-by-step motor [redacted]R-521. Development/scan on the time is produced with supply to the entry of the step-by-step motor of impulses/momenta/pulses from the generator whose frequency can be smoothly regulated (sweep oscillator on the time in Fig. 50). Cycling from the displacement pick-up makes it possible to carry out development/scan of process on the way. In this case the evenness of development/scan virtually is retained at any velocities of working stroke, there are no oscillations and delay of scanner with velocity jumps, etc.

The basic parts of displacement pick-up (Fig. 51) are disk 3 s tc slcts and its established/installed on both sidas illuminator and the photodiode (in the ficure they are nct shcwn).

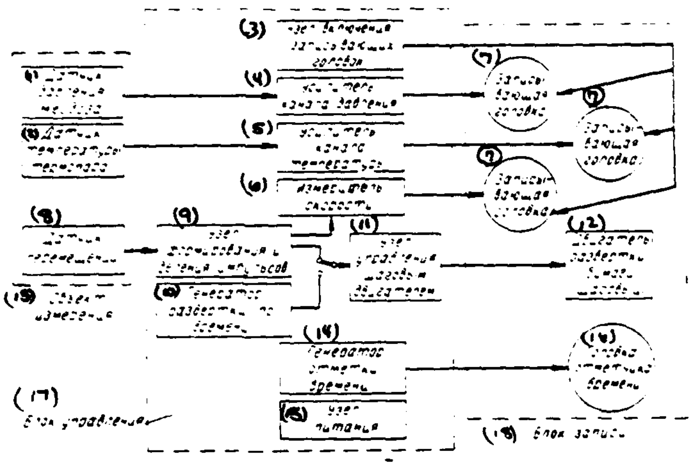

Fig. 50. Structural diagram of instrument for the simultaneous recording of pressure in the hydraulic system, the temperature of blank and velocity of the working stroke of hydraulic press.

Key: (1). Pressure sensor (dynamometer). (2). Temperature-sensing device (thermocouple). (3). Unit of start of recording heads. (4). amplifier of channel of pressure. (5). Amplifier of channel of temperature. (6). Speed/rate meter. (7). Recording head. (8). Displacement pick-up. (9). Unit of formation and division of impulses/momenta/pulses. (10). Sweep oscillator on time. (11). Control assembly of step-by-step motor. (12). Engine of development/scan of paper (step). (13). Object of measurement. (14). Generator of time mark. (15). Power unit. (16). Head of time marker. (17). Control unit. (18). Recording unit.

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With the working stroke of press the cable, attached by one end on the crosshead, drives receiving drum 2, which is connected with disk 3 through raising reducer 4. Recurrent drum 1, to which is wound the second end of the cable, serves for the tension of the latter and its return to the initial position with the back stroke of press. To this cable it can take up the sag between limiter 5 and cross-beam of press, as shown in Fig. 51, thanks to which is absent the accelerated rotation of reducer with the idling and appears the possibility of the execution of drum 1 by compact. The presence of brake in the reducer eliminates the effect of gaps. As a result is achieved the sufficiently stable work of displacement pick-up, in spite of the presence of reducer and flexible member of cable.

The rotation of disk with one or the other velocity leads to the appearance on the photodiode of the indicating lights, converted into the electric pulses whose number is proportional to the displacement of press. The formation of impulses/momenta/pulses in the amplitude and the duration is produced in the device of formation. Division of impulses/momenta/pulses is accomplished/realized separately along the channel of the recording of velocity (speed/rate meter in Fig. 50) and the channel of control assembly of step-by-step motor.

The impulses/momenta/pulses, which enter the speed/rate meter, are converted into the direct current of recording head whose value is proportional to pulse frequency, i.e., velocity.

Pressure sensor is extensometric bridge (dynamometer). One of the diagonals of bridge is written/recorded by sinusoidal alternating current from the master oscillator; from another diagonal is removed/taken the signal of unbalancing, proportional to the measured pressure. Balancing/trimming bridge on the capacity/capacitance and the effective resistance is accomplished/realized by two variable resistors.

Temperature-sensing device is thermocouple. The direct current, produced by thermocouple, is converted into alternating current with the aid of the special converter, assembled on the transistors.

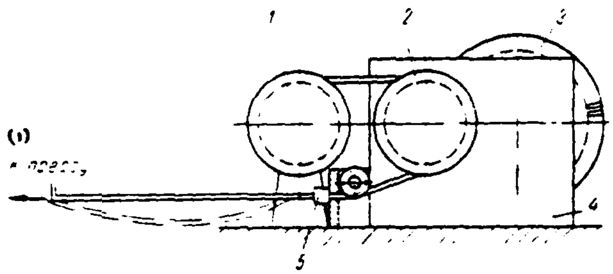

Fig. 51. Schematic of displacement pick-up.

Key: (1). To the press.

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The generator of time mark depending on adjustment can produce the electric pulses through 1; 2.5; 5 and 10 s. These impulses/momenta/pulses enter the entry of the recording head of time marker. In order to eliminate the effect of peak current during the supplying of supply voltage, the device of recording heads provides the per-second delay of their inclusion/connection.

Are given below the basic parameters of displacement pick-up.

Technical characteristic of displacement pick-up.

(1) Предельные значения:	
(2) записываемого давления (в зависимости от конструкции датчика) в кгс/см²	20—1000
(3) записываемой температуры (в зависимости от типа термопары) в °С	20—1300
(4) Минимальная записываемая скорость рабочего хода в мм/сек	0,5
(5) Минимальная скорость по отметкам времени в мм/сек	0,1
(6) Минимальное регистрируемое время рабочего цикла в сек	5
(7) Точность регистрации параметров в %	±5

Key: (1). Maximum values:. (2). written/recorded pressure (depending on construction/design of sensor) in kgf/cm². (3). written/recorded temperature (depending on type of thermocouple) in. (4). Minimum written/recorded velocity of working stroke in mm/s. (5). Minimum speed on time marks in mm/s. (6). Minimum recorded time of operating cycle in s. (7). Precision/accuracy of recording parameters in.

Instrument is reliable in the operation.

4. Mechanization of works.

The parts, stamped on the powerful/thick hydraulic presses, have large overall dimensions (to several meters) and mass (it reaches hundreds of kilograms). Operations on their transportation, packing into the die/stamp and the like are very labor-consuming. In this case the use/application of manual labor is inadmissible. At the same time the mechanization of the processes of the displacement of blanks and finished articles is conjugated/combined with the series/row of difficulties. Thus, with the great variety of forms and sizes/dimensions of the die-forced forgings it is necessary that the mechanizing device would be general-purpose. It must act smoothly with different height/altitude of stamp sets and relatively close stamp space.

The operations, which require mechanization, it is possible to subdivide into two categories: knockout from the die/stamp of finished articles; the supply of blanks and the removal/distance of finished articles.

Knockouts are installed in the center of press also on the bridge, to which is advanced the table. In the first case the knockout of finished articles is produced on the spot of stamping. Side knockout (on the bridge) acts with the advanced table. The mechanism of knockouts is one and the same: one or several hydraulic cylinders, fed by high-pressure liquid, with the plungers which through the system of beams/gullies and pushers produce knockout. Pushers are installed in the die/stamp into one or several series/rows depending on the width of part.

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Let us note that for the installation/setting up of knockouts is necessary drilling of through holes and milling slots/grooves in the die base-plates and the die/stamp. As a result in the latter increase the voltages. In order to avoid this, presses are equipped with the knockouts of the pulling action (Fig. 52), which work through the lever/crank system, installed on the bolster. During the use of this knockout the slots/grooves and holes for the thrusts and the pushers make only in the die/stamp.

Mechanization of the supply of blanks and removal/distance of finished articles can be solved as follows (Fig. 53) [12]. Blanks overhang from the furnaces by special transporters perpendicularly to the longitudinal axis of press. They fall to the chain conveyer of truck 2, subject to the window of the furnace (circuits of the transporter of truck enter between the circuits of furnace transporter). On its rail track the truck with the blank is moved to the longitudinal axis of press. Here blank is seized by charging manipulator 6, who on basic rail track of 7 is fixed to press 5. Manipulator 6 produces setting blank into the die/stamp. After stamping manipulator 3 picks up finished article and supplies him to second truck 2. The latter on its rail track supplies finished article to transporter-cooler 1, which transfers part into adjacent aisle. The work of mechanisms is accomplished/realized as follows. When manipulator 6 with the blank will drive up to the press, manipulator 3 takes away/gathers finished part. Stamping begins at the moment/torque when loading manipulator is removed from the stamp space of press.

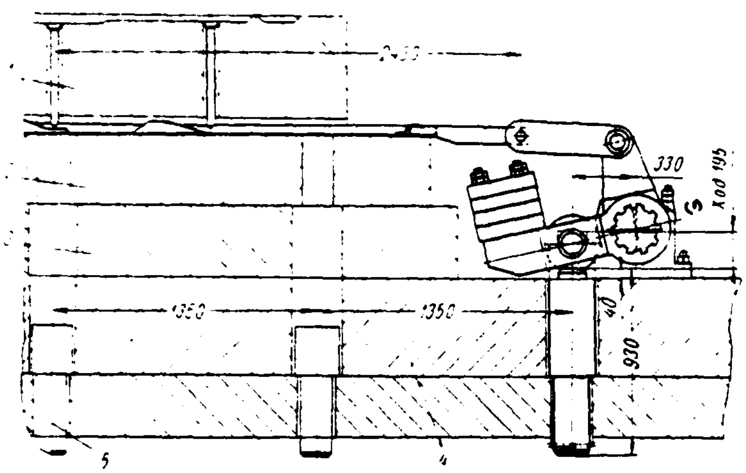

Fig. 52. The knockout of the pulling action: 1 - die/stamp; 2 - scwblock; 3 - plate/slab intermediate; 4 - table; 5 - axis/axle of press.

Key: (1). Course.

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The motion of manipulators along the rail track is limited to limit stops 8 and average/mear deterts 4.

Let us examine the device of separate mechanisms. Truck [12] (Fig. 54) is platform 3 or running wheels, on which is assembled the chain conveyer. Its circuits are driven by two electric motors which together with the brakes and by worm reducers 1 are arranged/located on shaft butt ends 4, which carries sprocket drives. Beams/gullies 7, which are encompassed by circuits 6, have arms, which make it possible to introduce the circuits of the truck between the circuits of furnace transporter or transporter-cooler. Idle chain wheels are arranged/located on these arms and are equipped with tighteners. Feeding to the electric motors of transporter is fed with the aid of flexible cable. Truck is moved from the hydraulic cylinder of the double action, given from its own hydraulic system. Control of truck and by its transporter, and also by furnace (or transporter-cooler) is concentrated on one panel. Operator produces the start of mechanisms. Upon reaching by the blank (or finished article) of the prescribed/assigned position the transporter of truck self-stopping.

Charging and discharging manipulators have the identical construction/design (Fig. 55). Basic part of each of them is the bridge, moving to four running wheels on the rail track. Bridge has of the plan/layout U-shaped form and consists of two stringers 7, connected by cross-beam 9. The latter is made in the form of arch and with manipulator's entrance into the stamp space does not prevent his motion. Cross-beam is located above the lower die base-plates. Furthermore, because of the arched cross-beam manipulator can pass above the truck with the blank or the finished part.

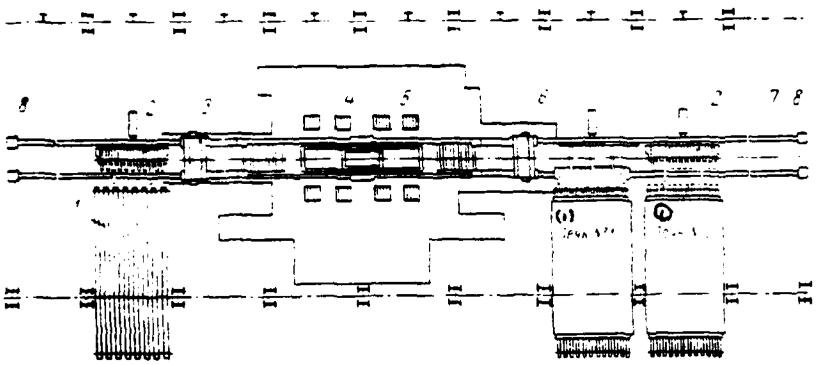

Fig. 53. Equipment for mechanizing press [12].

Key: (1). Furnace.

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On the cross-beam is arranged/located the panel for machinist, who controls manipulator, and also different by hydro- and electrical equipment. On the cross-beam is located also drum 8, to which is wound flexible cable, which supplies feeding to rear running wheels (front/nose wheels - nondriven). For each of them is fastened/strengthened reducer 10, led to its rotation by electric motor.

Principal part of the manipulator is frame 1 with the captures/grips, which moves over two vertical columns 3, fastened/strengthened to the bridge. Frame is rigidly connected with two carriages 5, moving under the action of hydraulic cylinders 6.

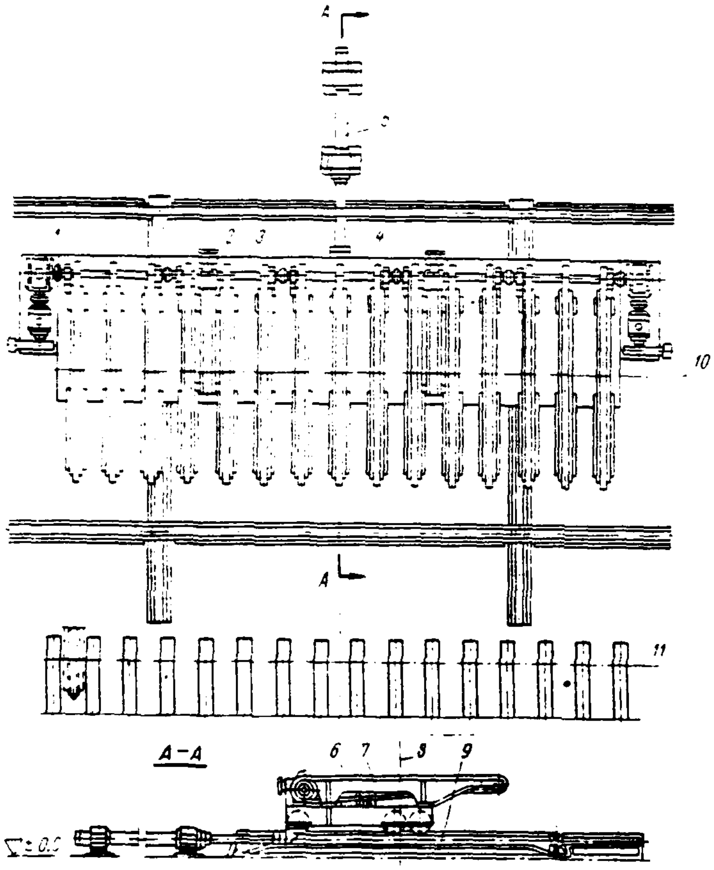

Fig. 54. The truck: 1 - reducers; 2 - detents; 3 - platform; 4 - shaft of sprocket drives; 5 - hydraulic cylinder of the displacement of truck; 6 - circuit of transporter; 7 - beam/gully; 8 - the longitudinal axis of press; 9 - apron of press; 10 - the longitudinal axis of press; 11 - axis/axle of the chain wheels of furnace transporter or cooler.

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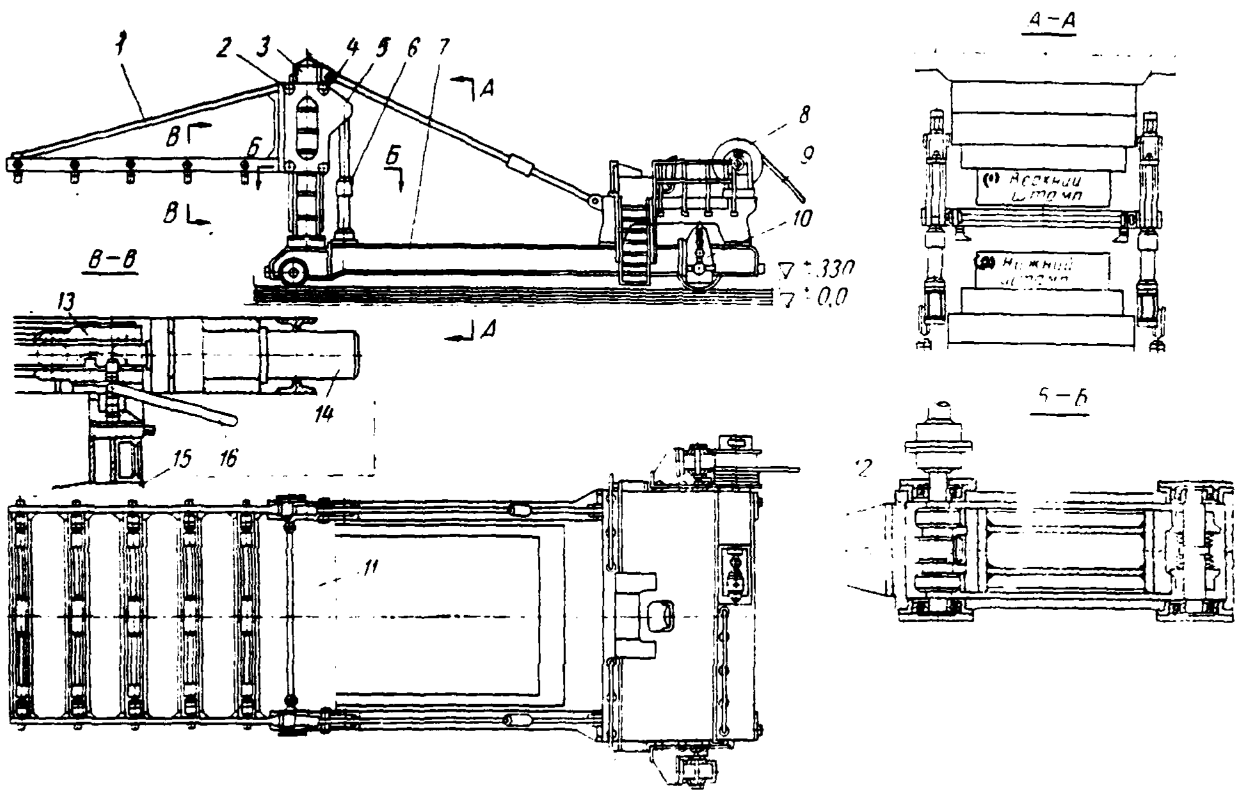

Fig. 55. Manipulator [12].

Key: (1). The upper die. (2). Bottom die.

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Carriages move over the columns on four pairs of cylinders. Cylinders

4 and 12, which receive torque load from the load, have straight tread, and unloaded cylinders 2 - spherical. The latter fix/record the position of frame relative to columns in the transverse direction because of the set of disc springs. In this case the springs compensate the thermal deformations of the frames which can reach the significant magnitude, since manipulator transports the heated metal.

The bottom loaded cylinders are made for one whole with the gear, entering the engagement with the rack which is fastened/strengthened to the column. Gears of both of carriages are connected with shaft 11 and couplings, which prevents the misalignments of frame during its action.

Frame bears five pairs of catches 13, each pair having individual hydraulic drive (cylinder of double action 14). Capture/grip has four cylinders, which make it possible for it to be moved on the guides. In the capture/grip there is the hole, through which freely is passed the stock/rod of hydraulic cylinder. Conical bores in the stock/rod and locks of 16 captures/grips make it possible to fasten the latter in the different places of stock/rod and thereby to regulate the distance between the captures/grips, which depends on the overall dimensions of blank or finished die-forged forging. The operating units 15 of capture/grip (hook) are interchangeable. Their form (construction/design) selects depending on the form of article, which they must seize. The latter fact in combination with the adjustable distance between the captures/grips makes manipulator to the known degree with general-purpose.

Mechanization of the operations of transportation can be different. For example, on the presses "Levi's"effort/force 31500 and 44500 T apply not rail, but outdoor/floor manipulators.

Furthermore, the flights/spans where are established/installed powerful/thick presses, equip with bridge cranes. In this case the taps/cranes move at two different levels over the height/altitude of flight/span. Lower taps/cranes by load capacity 30-50 T are intended basically for die setting and other auxiliary operations; upper, that have large load capacity, for replacing the plates/slabs of stamp set.

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As far as lower cross bars are concerned, on stress distribution in them has an effect the character of the loading of the base/root of press. This especially is developed with the loadings with the longitudinal eccentricity [1] when the maximum stresses/voltages it is shifted/sheared to the extreme plate/slab of cross bar in the direction of center-of-pressure travel.

FOOTNOTE. [1]. Research data of press model. ENDFOOTNOTE.

In the guides of 4 crossheads (Fig. 69) in the presence of eccentricity, but in the inoperative basic system of the elimination of misalignment, stress/voltage in sections/cuts I-I they reach 1200 kgf/cm². When this system works, the stresses/voltages indicated do not exceed 400 kgf/cm². In the form of bundles longitudinal 2 and transverse 1 plates/slabs of different section/cut and connected with each other by tie pins 3, resembles the system of cross beams/gullies which frequently is applied in the structures. True, in contrast to the latter the part of the beams/gullies of cross-beams has small length at considerable height/altitude (L/h=3-4), i.e., is beam partitions. In this case forces of friction on the mating surfaces trouble the strain of cross-beam.

The calculation of a similar construction/design is complex in connection with the repeated static indefinability of system and the difficulty of the account of such factors as forces of friction, tightening of pins, consistency of the work of separate elements/cells, stress concentration, contact corrosion, elastic compression of beams/gullies, etc.

The preliminary investigation of stress distributions in the beam partitions with different L/h made it possible to conclude that during the calculation of beam partitions with L/h=3-4, loaded similarly to the longitudinal plates/slabs of cross-beams, it is possible to utilize impedance methods of materials [33].

Calculation data checked on the models of the cross-beam of press by the effort 7500C T (to scale 1:37 to the full-scale construction/design), made from fiberglass and metal, for press and its working model.

Table 14 gives the values of stresses/voltages and sagging in the elements/cells of the crosshead of press effort/force 75000 T, obtained by different methods, and also averaged date of experiments on the models.

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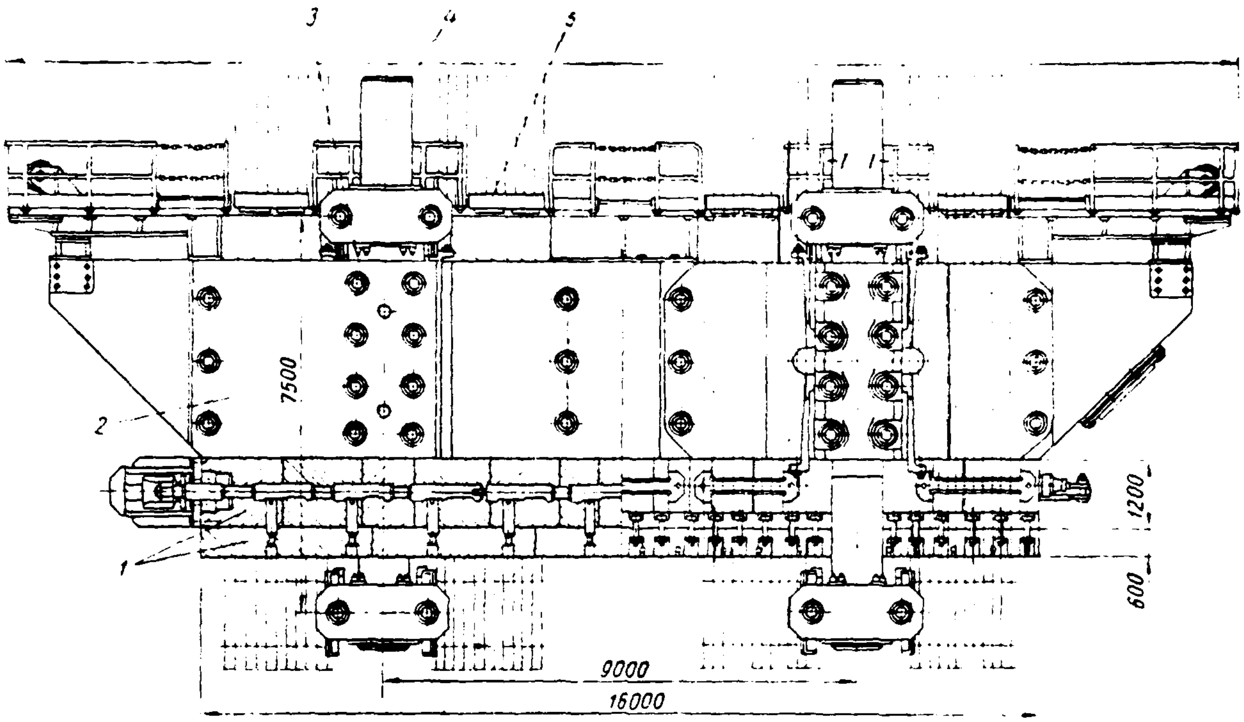

Fig. 69. Crosshead of press by effort/force 75000 T: 1 - transverse plates/slabs (supporting beams); 2 - longitudinal plates/slabs; 3 - tie pins; 4 - being guided; 5 - transverse under-cylinder plates/slabs.

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In the process of the investigation of cross-beams on the press by effort/force 75000 T and its acting model primary attention was given to questions of the nonuniformity of the work of the plates/slabs of composite/compound constructions/designs, to the effect of the form of loading on the stressed state of cross-beams, to interaction of cross-beams with the mating members, to the development/detection of the real deformations of cross-beams in the central zone (effect of sagging on the precision/accuracy of the articles to be stamped). Wire-type strain gauges were established/installed in three sections/cuts on the ends/faces of the longitudinal plates/slabs: below the fixed cross-beam (Fig. 70); from above the crosshead and on the lateral surfaces of external plates/slabs at three points on the height/altitude of central section/cut. Maximum stresses/voltages in both cross-beams (1000-1100 kg/cm²) are obtained in the center of average/mean plates/slabs (for example, for the fixed cross-beam section/cut II-II in Fig. 70).

Table 14. Stresses/voltages (in kgf/cm²) on the tension fibres of the mean section of cross-beam, sagging in the center of cross-beam.

(1) Способ определения	(2) Продольные балки			(3) Поперечные балки			(10) Прогиб в мм
	(4) крайние	(5) промежуточные	(6) средние	(7) средние опорные	(8) средние подцилиндровые	(9) крайние подцилиндровые	
(11) Расчет	555	897	1275	1604	678	55	7,1
(12) Эксперимент на моделях	600—640	900	1160—1190	1500	540—570	100—120	6,3—6,8

Key: (1). Method of determination. (2). Stringers. (3). Cross beams. (4). extreme. (5). intermediate. (6). average/mean. (7). average/mean supporting/reference. (8). average/mean under-cylinder. (9). extreme under-cylinder. (10). Sagging/deflection in mm.

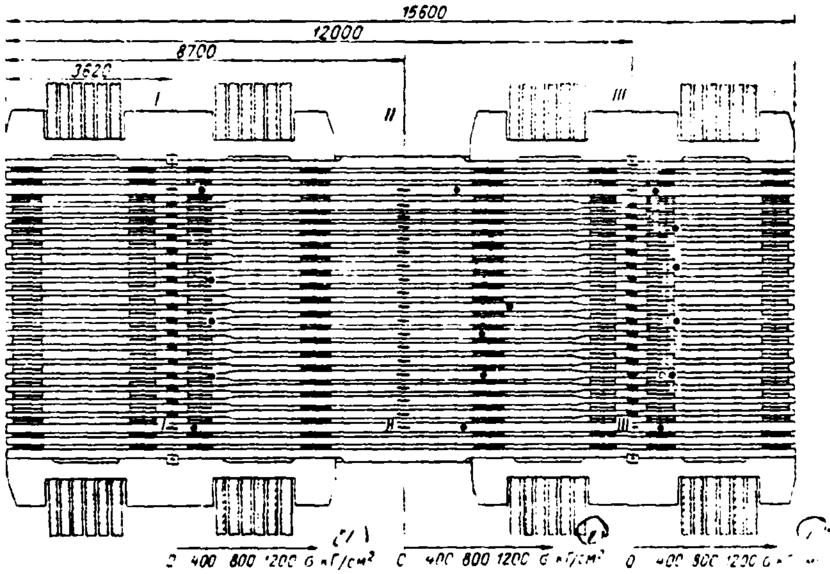

Fig. 70. Arrangement of extensometers and stress distribution on the lower ends/faces of the plates/slats of the base/root of press by effort/force 75000 T. ● -full-scale sample/specimen; ○ -model.

Key: (1). kgf/cm².

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In the sections/cuts between the outer and average/mean frames (I-I and III-III) the stresses/voltages are decreased approximately/exemplarily by half. The presence of longitudinal eccentricity virtually does not have an effect on value and character of stresses/voltages in the rear section. At the same time in other sections/cuts stresses/voltages along one side from the center of the press (it is nearer to the center of pressure) grow/rise, and on opposite side they are decreased on the average by 15-20o/o. Transverse eccentricity does not affect stresses/voltages in the cross-beams.

The nonuniformity of operation of longitudinal plates/slabs can be described by coefficient, i.e., by the relation of tensile stresses on the external filaments of average/mean and extreme plates/slabs. The value of this coefficient (in average/mean 1.3) is lower than the value, obtained by the calculation (see Table 13).

From the side of stamp set to the transverse plates/slabs of the crosshead and base/root act considerable tangential forces. Because of this the neutral lines of the transverse members are misaligned to the side of stamp set.

The greatest shift of neutral line (Fig. 71) is observed in the middle part of the longitudinal plate/slab, moreover stress/voltage on the free contour/outline in the absolute value on the average on 50o/o more than stresses/voltages in the place of contact with the supporting beams.

Let us examine the effect of the tightening of pins on the stresses/voltages in the crosshead, studied on its metallic model [24].

Measurements were produced with the following versions: were tightened all pins; were weakened six middle horizontal pins; were weakened all horizontal pins and were weakened all pins.

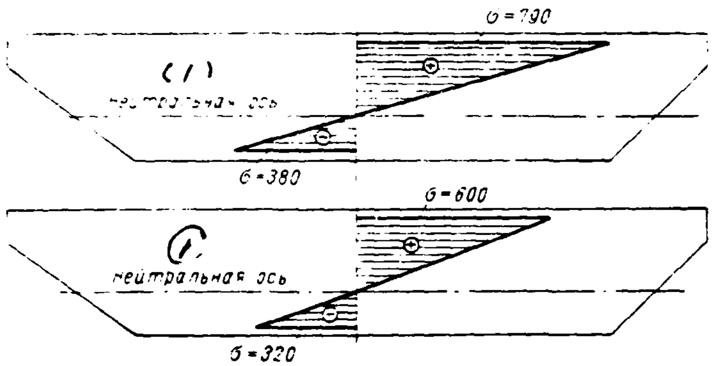

Fig. 71. Shift of neutral line on the height/altitude of the bundle of the crosshead of press by effort/force 75000 T.

Key: (1). Neutral axis/axle.

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The tightening of horizontal pins was accomplished/realized with the aid of the torque wrench with the interference to 50-55 kgf, vertical - by hand (without the key/wrench).

Experiments showed that in the cases of weakening vertical and horizontal pins occurs the redistribution of the efforts/forces, which effect on the separate parts of cross-beam.

The greatest effect exerts weakening horizontal pins. In this case the stresses/voltages in the base plates increase (Fig. 72, 73), and the nonuniformity of stress distributions according to the longitudinal plates/slabs grows/rises. Thus, during weakening of six middle pins stresses/voltages in the base plates increase to 20-40o/o (see Fig. 73), and the nonuniformity of stress distributions according to the longitudinal plates/slabs grows/rises from 1.6 to 1.9 (Fig. 74). Stresses/voltages in the under-cylinder plates/slabs also increase.

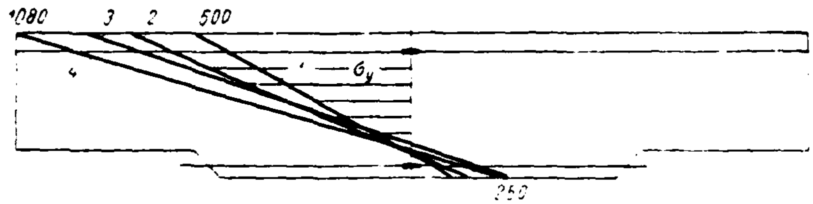

Fig. 72. The dependence of stresses/voltages σ_y in the mean section of supporting beam (plate/slab) from the tightening of pins [24]: 1 - all pins are tightened; 2 - are weakened six average/mean horizontal pins; 3 - are weakened all horizontal pins; 4 - are weakened all pins.

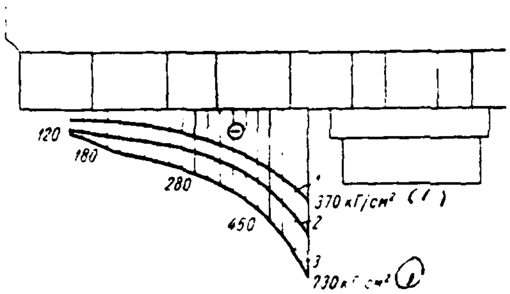

Fig. 73. Dependence of stresses/voltages σ_y on lower edge of base plates from tightening of pins [24]: 1 - all pins are tightened; 2 - are weakened six middle horizontal pins; 3 - are weakened all horizontal pins.

Key: (1). kgf/cm².

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With weakening of all horizontal pins the stresses/voltages in the base plates and under-cylinder plates/slats increase by 80-100o/o, and in the central base plate - to 50o/o; the nonuniformity of stress distributions according to the longitudinal plates/slabs grows/rises to 2.0-2.2.

During weakening of vertical pins the stresses/voltages increase only in the extreme under-cylinder plates/slabs. During weakening of all pins the stresses/voltages in the average/mean supporting/reference and under-cylinder plates/slabs increase, the nonuniformity of stress distributions according to the longitudinal plates/slabs grows/rises.

Consequently, the greatest effect on the redistribution of stresses/voltages has the tightening of the horizontal pins which tighten longitudinal plates/slabs, and especially the tightening of six pins, arranged/located in the middle part of the plates/slabs. The tightening of pins leads in essence to a change in the stresses/voltages in the transverse plates/slabs. In longitudinal plates/slabs the value of stresses/voltages changes to a lesser degree.

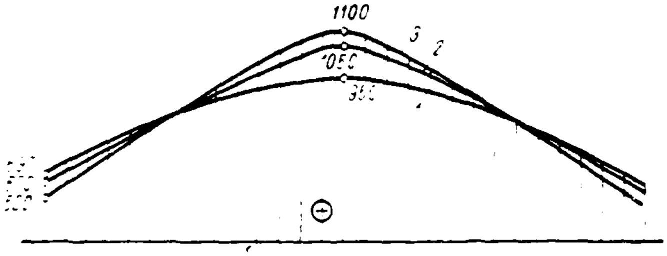

Fig. 74. The dependence of stresses/voltages σ_x on the upper edge of the mean section of longitudinal plates/slabs from the tightening of pins [24]: 1 - all pins to tighten; 2 - are weakened six middle horizontal pins; 3 - are weakened all horizontal pins.

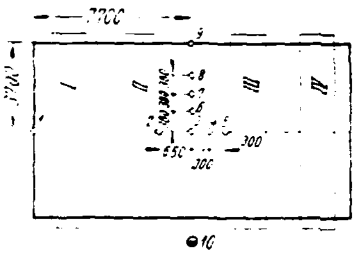

Fig. 75.

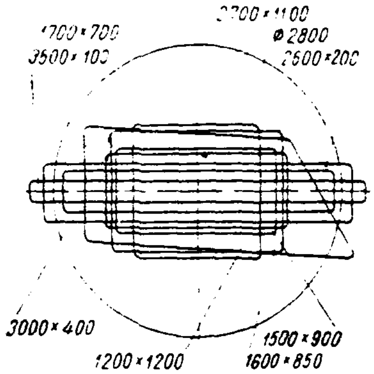

Fig. 76.

Fig 75. Arrangement of indicators in measurement of saggings/deflections of base/root of press by effort/force 75000 T: I-IV - frame of press; 1-9 - indicators; 10 - control panel.

Fig. 76. form of blanks and ingots in plan/layout during deformation

of which was measured sagging/deflection of base/root of press by effort/force 75000 T.

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Under the press effort/force 75000 T on the foundation for the measurement of the saggings/deflections [1] of base/root established/installed special struts with attached in them indicators.

FOOTNOTE [1]. Actually into the measured value besides sagging/deflection enters also the elastic compression of the plates/slabs of cross-beam. ENDFOOTNOTE.

In this case central strut was with the cross piece for fastening of several indicators in the directions of the longitudinal and transverse axes of base/root. The diagram of the layout of indicators is shown in Fig. 75.

The first stage of measurements had as a goal to explain the effect of the form of article or the value of the elastic bend of cross-beam, and to also determine actual bending deflection with different steps/stages of effort/force.

Fig. 76 on one scale shows in the plan/layout the form of those blanks and ingots during deformation of which were measured the saggings/deflections by indicators 1, 3, 9. Table 15 gives the averaged values, obtained on the basis of a large number of measurements (dispersion/dissipation of readings/indications in this case did not exceed 10o/o of average value).

From the examination tables 15 it follows that for the practical targets the value and the character of elastic deformation of the bend of cross-beam are determined only by the value of strain and do not depend on form and sizes/dimensions of forging, since the set of die base-plates provides identical load distribution on the cross-beam during stamping of different articles.

After comparing calculated f^{np} and experimental f^{n} of the value of the arrow/pointer of longitudinal sagging/deflection, we detect a good convergence.

Table 15. the saggings/deflecticns cf the lower cross-beam cf press by effort/force 75000 T during stamping of different articles.

(1) Габаритные размеры изделий в мм	(2) Номер индикатора (Рис. 75)								
	3			6					
	(3) Ступени усилия в Т								
	49 000	62 000	75 000	49 000	62 000	75 000	49 000	62 000	75 000
2700 · 1800	3.40	5,14	5,635	1,94	3.2	3,42	0,10	0,22	0,18
1670 · 800	3.30	—	—	2,10	—	—	0,19	—	—
2000 · 850	3.36	—	—	1,98	—	—	0,15	—	—
2300 · 400	3,50	4,80	—	2,10	3,3	—	0,20	0,24	—
⌀ 2800	3,12	4,72	5,620	2,04	2,25	3,55	0,09	0,19	0,17
1200 × 1200	3,40	—	—	2.0	—	—	0,30	—	—
1700 × 700	3,39	—	—	2,11	—	—	0,31	—	—
2600 × 400	3,33	—	—	2,0	—	—	0,33	—	—
3500 × 200	3,34	—	—	2,0	—	—	0,33	—	—

Key: (1). Overall dimensicns cf articles in mm. (2). Number cf indicatcr (Fig. 75). (3). Steps/stages of effcrt/force in T.

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Thus, according to the calculation

$$f_p^{np} = 6{,}8146 - 0{,}93 = 5{,}885 \text{ мм},$$

actual value comprises

$$f_3^{np} = 5{,}635 - 0{,}18 = 5{,}455 \text{ мм}.$$

Difference ccmposes -7o/c.

The longitudinal and lateral stiffness of crcss-beam are approximately/exemplarily identical, which is confirmed by the following values of relative bending deflecticn:

$$f_3^{np} = 0{,}34 \text{ мм/м}; \; f_3^{n} = 0{,}28 \text{ мм/м}.$$

For the more complete judgment about the effect the rigidity of cross-beams to the precision/accuracy of the articles to be stamped it is necessary to know the form of the warped surface of cross-beam in the limits of the area of forging, for example in the section/cut along the longitudinal or transverse axes of press. Such data (averaged on the basis of many measurements) were obtained for steps/stages the I and II efforts/forces of press by effort/force 75000 T during stamping of the parts of rectangular planform (table 16).

From table 16 it follows that the bend of cross-beams virtually does not affect the variation in thickness of the part to be stamped. Investigations showed that the crosshead is deformed analogously with fixed.

Table 16. Deformation (in mm) of the lower cross-beam of press by effort/force 75000 T for steps/stages of the I and II effort/force.

(1) Усилие в Т	(2) Номер индикатора (рис. 75)								
	1	2	3	4	5	6	7	8	9
49 000	0,37	3,75	3,7	3,6	3,56	3,75	3,75	3,66	2,25
62 000	0,57	4,25	4,2	4,0	4,05	4,50	4,75	4,90	3,32

Key: (1). Effort/force in T. (2). Number of indicator (Fig. 75).

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4. Special features/~~peculiarities~~ of the behavior of stamp sets with the loading of press.

With the loading of press the dies/stamps and die base-plates are found under conditions of the complicated stressed and strained state, being they are subjected to compression and bend. If we consider in this case that the stamping is accomplished with the specific efforts/forces, which reach by 60 kg/mm² and more, and that the plate/slab (especially arranged/located nearer to the die/stamp, to say nothing of die/stamp itself) work at elevated temperatures and to a considerable degree are weakened different kind by slots/grooves and holes, then are completely probable not only the elastic, but also residual deformations of stamp set. Both those and others negatively affect the precision/accuracy of stamping.

Experience of operating the powerful/thick stamping machines of different constructions/designs makes it possible to make the conclusion that the residual shaping of die base-plates is consequence, at least, three factors: wear, fatigue breaking-off and the elastoplastic bend. The greatest wear, depending on the shift of plates/slabs relative to each other, must be observed on the edges where the shifts is maximum. Therefore, if shaping affects only wear, the form of plates/slabs must be biconvex.

In the presence only of fatigue breaking-off the form of plates/slabs must be biconcave, since in this case the maximum of shaping is in the center where are most great contact pressures.

Finally, the elastoplastic bend makes the form of the plates/slabs of convexo-concave.

Three factors indicated, as a rule, act simultaneously, some one of them can have the decisive effect on shaping of die base-plates.

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Measurements from the working and bearing surfaces of the lower sowblock of press by the effort/force 30000 T of UZTM [- Ural Heavy Machinery Plant] (Fig. 88a-c) made it possible to establish that in them was observed the tendency toward the convexo-concave form although in some sections/cuts (for example, Fig. 88b) of both of surfaces (in the center) it occurred convexity. Consequently, shaping this plate/slab appears mainly due to the elastoplastic bend and the wear.

Let us note that if the prevailing factor of shaping is the elastoplastic bend, then the accumulation of residual deformation depending on a number of cycles of loading carries the damped character. It virtually ceases after a comparatively small number of cycles of loading. Fig. 89 shows the accumulation of residual deformation at the central point of different die base-plates of the model of press by effort/force 75000 T. These data can be attributed also to the plates/slabs of press itself.

All this shows that the plates/slabs work under conditions of the low-cycle fatigue, which is characterized by the intense accumulation of residual deformation with the repeated static loadings. It is known that the low frequency of alternating loading, especially in combination with the holding with the peak load, causes large residual deformation in comparison with the same at the high frequency of loading. The determination of the boundary/interface of elastic resistance for the state of plane stress, which corresponded to working conditions of die base-plates and dies/stamps, showed that the so-called cyclic yield point of the material of plates/slabs to 23o/o lower than static, using which usually is performed the calculation of plates/slabs (to the strength [9].

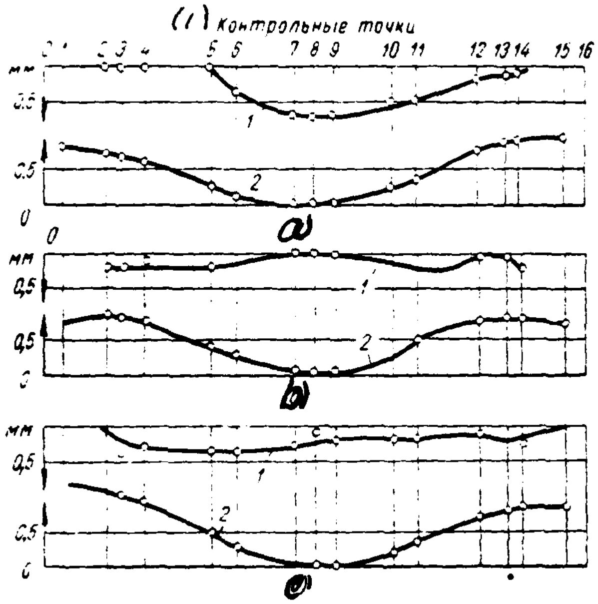

Fig. 88. Residual shaping of the working and bearing surfaces of the lower sowblock of press by the effort/force 30000 T of UZTM. 1 - worker and 2 - supporting/reference of side.

Key: (1). Control points.

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It is at the same time known that the necessary increase in the resistivity to shaping it is possible to achieve, utilizing the surface work hardening/peening which creates a layer of favorable residual stresses/voltages. Theoretical analysis and experiments on the models showed that for this it suffices to plastically deform plate/slab at depth 50/c of its height/altitude. The specialized equipment for the stamping (whatr it is noted in the work [9]) it makes it possible to obtain the work-hardened layer with a depth up to 30 mm, which can give necessary effect.

The analysis of the loading of samples/specimens with the frequency from several cycles per minute to several cycles in a 24 hour period with the total number of cycles, which reaches to hundred and thousand (similar frequency is characteristic for the loading of die base-plates), shows that with an increase in the frequency of loading increases the endurance limit [11].

If we designate $K_{mp} = \frac{\sigma_{mp}}{\sigma_T}$ (σ_{mp} — the stress/voltage of aging/training; σ_T — yield point), then with the repeated constant-sign bend the accumulation of plastic deformation will be considerable even when $K_{mp} = 0{,}65$, but the process of the accumulation of plastic deformation is stabilized already after the first 250 cycles. When $K_{mp} = 0{,}9$ the amount of plastic deformation at the moment/torque, corresponding to the stabilization of process ($K_{mp} = 0{,}65$), will be 4 times more than in the preceding case.

With the repeated static loadings it can happen so that steel with the higher yield point considerably more intensely accumulates plastic deformation than steel with the lower yield point.

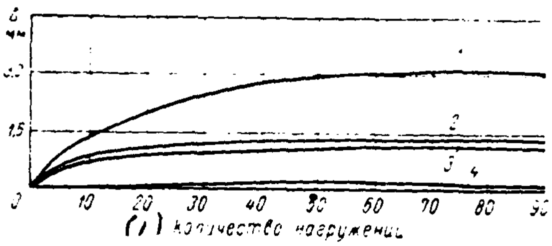

Fig. 89. The accumulation of residual deformation at the central point of different die base-plates of the model of press by effort/force 75000 T (in the conversion to nature): 1 - lower and 2 - upper sowblocks; 3 - lower and 4 - upper backing plates.

Key: (1). Quantity of loadings.

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In other words, an increase in strength of steel with the single loading can not lead to the appropriate increase in its repeated static strength. It is necessary that with an increase of yield point to the same degree would be increased ultimate strength. Therefore during the determination of allowable stress for the plates/slabs of stamp set should be considered not so much yield point, as those properties of material, which are specific for the repeated static loading (in particular, the difference between the yield points and strength).

The stabilization of an increase in the plastic deformation of plates/slabs in the case of their elastoplastic bend is the consequence of the emergence in them of the residual stresses/voltages: stretching on the working (compressed) and compressive on the supporting/reference (elongated) surfaces (residual stresses/voltages apply to certain distance depthward of plate/slab). The amount of plastic deformation the greater, the greater is loaded the plate/slab. In other words, plastic deformation is more in the plates/slabs, arranged/located nearer to the die/stamp.

Let us note that after the accumulation of plastic deformation actually paused itself, it can be renewed with an increase in the time of the single loading of press. The presence of the residual deformation of plates/slabs changes their stressed state during the loading. Under the action the efforts/forces of the press of plate/slab can partially be straightened/rectified, attempting to assume the form of the bent with the loading cross-beam. Then in the sections where in the nondeformed plates/slabs one should expect compression, is observed elongation, and vice versa.

In spite of the stabilization of the residual shaping of die base-plates, it entails the series/row of the undesirable phenomena and, first of all, negatively it affects the precision/accuracy of stamping (with the concave character of the working surface of plates/slabs). If to the sowblock with the concave working surface is established/installed new die/stamp, then at the first moment of loading is eliminated the clearance between it and by sowblock, i.e., occurs the bend of die/stamp. Further, with the partial straightening of plates/slabs die/stamp is bent in the opposite direction. Such repeating loadings after several cycles give Ci to the residual shaping of die/stamp, and this, in turn, calls an increase so in that called increase of their variation in thickness.

The convexo-concave and biconvex forms of plates/slabs adversely affect the loading of press and contribute to concentration of load.

For eliminating the residual deformation, besides the already mentioned work hardening/peening, with the elastoplastic bend it is possible to recommend the periodic planing of the working surface of sowblocks (under the condition of retaining/preserving/maintaining the form of remaining plates/slabs, obtained by them during the plastic deformation).

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With the planing is removed/taken a layer of minimum thickness, in order to preserve the zone of favorable residual stresses/voltages. It is logical that the restored sowblock cannot operate with the die/stamp, which obtained residual deformation, since this again causes the appearance of plastic deformation of sowblock due to the increased contact pressures in the central part of it of working surface.

Finally, during the construction of equipment in it one should provide a minimum quantity of slots/grooves and holes of technological designation/purpose also as far as possible to avoid their presence in the central, most load range.

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In the press with effort/force 75000 T of NKMZ-VNIIMETMASh (Fig. 108) used the system of the limitation of the misalignment of cross-beam, which relates to group II. Let us note that as one of the sensitive elements/cells in it is used the system of four synchronizing cylinders of the type, shown in Fig. 104 (simultaneously synchronizing cylinders absorb the small part of the power moment/torque of the eccentricity).

In order to decrease the effect of the deformation of liquid on the value of misalignment and to increase the sensitivity of system, it is filled with hydraulic fluid (46.3o/o of glycerin, 19.2o/o of alcohol, 2o/o of anticorrosive additives, the other water), the modulus of elasticity of which comprises $3.45 \cdot 10^4$ kgf/cm², i.e., almost 2 times higher than the modulus of elasticity of spindle oil. For the same target the hydraulic fluid in the system is located under the constant pressure 160 kgf/cm².

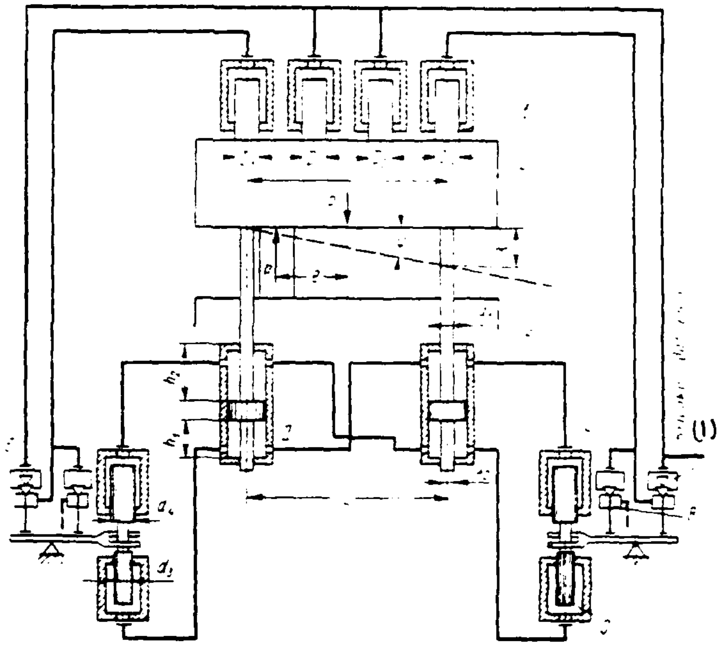

Fig. 108. The schematic diagram of the system of the limitation of the misalignment of the crosshead of press with effort/force 75000 T: 1 - working cylinder; 2 - movable cross-beam; 3, 4 - cylinders of the drive of throttle valve; 5 - synchronizing cylinder; 6, 7 - throttle valves; 8 - drain valve; D_1 - D_4 - diameters of working cylinders; P - resultant of effort/force; ϵ - eccentricity; λ - angular displacement of movable cross-beam; φ - angle of rotation of cross-beam; d_1, d_2 - diameters of piston and stock/rod of the synchronizing cylinders; h_1 and h_2 - respectively the height/altitude of the cavities of the synchronizing cylinders; L - distance between their axes/axles; d_3, d_4 - diameters of the plungers of the drive of throttle valve.

Key: (1). High pressure.

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The synchronizing cylinders by special conduits/manifolds are connected with the cylinders of the drive of throttle valves. The plungers of these cylinders through the lever/crank system move the stocks/rods of throttle valves and drain valves.

The upper plungers of the cylinders of the drive of chokes/throttles have somewhat larger diameter, than lower. This is provided for so that with the work of press without the eccentric load would be supported full gate of throttle valve.

System works as follows. With the misalignment of the crosshead, caused by the eccentric application of load (angular displacement λ and angle of rotation φ), will be raised the pressure in line I of synchronizing cylinders 5 (pressure in line II in this case will be lowered). Because of this with the pressure increase on the specific value the stocks/rods of cylinders 3 and 4 (in Fig. 108 to the right, on the side of misalignment) will move upward. Through the lever/crank system their motion is transmitted to throttle valve 7. The latter will begin to be closed. As a result the pressure in the angular working cylinder 2, will fall. Simultaneously throttle valve

6 will begin to be moved upward, decreasing resistance for the pass of liquid into the angular working cylinder D_1. With a change of the pressure in the angular cylinders the resultant of the effort/force of press is combined with the actual center of pressure of blank, removing in this case eccentricity. Consequently, in the process of throttling/choking the displacement of the stocks/rods of cylinders 3 and 4 virtually depends only on angular displacement. In other words, if we visualize that the liquid, included in the system of the synchronizing cylinders, is incompressible (to eliminate the effect of the elasticity of liquid on the displacement of the stocks/rods of cylinders 3 and 4 drives of throttle valve), then in the beginning of the operation of choke/throttle will occur the stiffening joint between the rotation of cross-beam and the displacement of throttle valve.

Let us note that in different positions of throttle valve in the dependence on its construction/design can not appear (balanced throttle valve) or appear (unbalanced throttle valve) the active effort/force, which effects on the throttle valve from the side of flow. In the second case this effort/force will store/add up to the effort/force, moving the stocks/rods of cylinders 3 and 4, and, thus, contribute to an improvement in the sensitivity of system.

Drain valve 8, established/installed in the system, is intended in order during the complete overlap by the throttle valve of delivery conduit to completely unload working cylinder from the pressure. With the maximum eccentricity (longitudinal 600 and transverse 200 mm) nominal effort/force descends with 75000 T to 70000 T. Misalignment must not exceed 0.3 mm/m (longitudinal) and 0.6 mm/m (transverse). The described system facilitates the conditions for the work of press and it recommended well itself in the process of its operation.

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The procedure of its calculation is contained in the work of B. V. Rozzanov and V. P. Lints [1].

FOOTNOTE [1]. The "automatic elimination of the misalignment of crosshead in the hydraulic stamping machines". "forging and stamping production", 1961, No 6. ENDFOOTNOTE.

Are given below the experimental data, which characterize the dynamics of the work of the press of press with the described system.

With the central and eccentric loadings of press oscillogramed the following parameters:

the course of the crosshead (idle, worker, reverse/inverse);

valve travel of the distributor of working cylinders;

valve travel of distributor of the hoisting and balancing cylinders;

pressure in the line of outer working cylinders;

pressure in the line of pitch working cylinders;

pressure in the line of hoisting cylinders;

pressure in the line of the balancing cylinders;

pressure in the angular working cylinders;

the course of throttle valves;

pressure in all four lines of the synchronizing cylinders;

the longitudinal and transverse misalignments of the crosshead.

The installation diagram, utilized during the experiment, is shown in Fig. 109. Oscillographing was produced on two train extensometric installations OT-24-51.

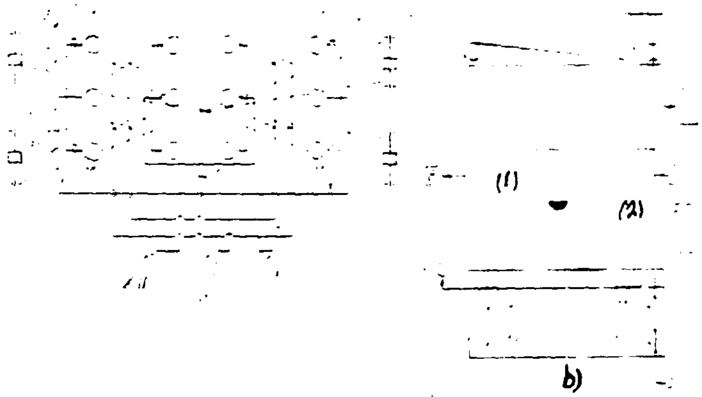

Fig. 109. The diagram of installation of measuring equipment during the experimental investigation of the system of the limitation of the misalignment of the crosshead of press by effort/force 75000 T: a - arrangement/position of dynamometers (pressure sensors); b - arrangement/position of hodographs (6 - crosshead; 7 - transverse misalignment; 8 - longitudinal misalignment; 9-12 - throttle valves): 1 - working cylinders; 2 - hoisting cylinders; 3 - balancing cylinders; 4 - throttle valves; 5 - synchronizing cylinders; I-XIII - dynamometer.

Key: (1). Panel. (2). Elevator.

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For the recording of the course of crosshead, and also displacements of the racks of the cylinders of the drive of distributors was used the slide-wire sensor (hodograph) (see Fig. ~~109~~ ~~49~~. 49.

Strokes of throttle valves were recorded with the aid of the two-string hodographs each of which was connected with the potenticmetric diagram (Fig. 109b, hodographs 9-12). The motion of valve stem was transmitted to the textolite slider with two brass contacts. Slider was moved on special guide.

For measuring the misalignments of the crosshead was developed the hodograph (Fig. 109b hodographs 7, 8) whose schematic was shown in Fig. 110.

At the ends of cross-beam 1 are established/installed rollers 3, across which is thrown cable 2. The end of the cable is attached on lift well, not connected with the press. Cover plate 8 links cable with toothed rack 7. the tension of cable is accomplished/realized by a set of loads 9, placed into oil cylinder 10.

During the motion of cross-beam without the misalignment the rack is fixed. With the advent of a misalignment the rack is moved upward or down (depending on the direction of misalignment). Forward motion of rack is converted into rotary motion of gear 6, which sits on one shaft with drum 5, to which are wound two strings of hodograph. The electrical circuit of this hodograph in essence is analogous to diagram in Fig. 49a; difference lies in the fact that here moving elements/cells are the strings, and contacts 4 are fixed. The extent of the movement of strings so much once is more than the extent of the movement of rack, in how often the diameter of drum of more than the diameter of gear.

The measurement of pressures was conducted with the aid of the dynamometers on the wire-type strain gauges with the base 10 mm and resisting of 115 ohms, established/installed in the appropriate lines of the hydraulic system (see Fig. 109a), and they checked by the manometers, placed there, where are dynamometer. Simultaneously were fixed/recorded voltages with equipment of the control (see section 3, Chapter III), established/installed on the struts of press.

Experiments were run with the residue/settling of the eccentrically arranged/located heated ingots, and also with the rigid presses (without upsetting) to the already deformed ingots (sizes/dimensions and the material of ingots, and also the sizes/dimensions of eccentricities see in section 3, Chapter IV).

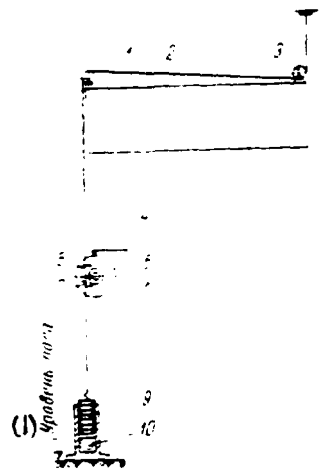

Fig. 110. Hodograph for the reccrding of the misalignment of the crcsshead.

Key: (1). Flccr level.

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The graphs, obtained after the interpretation of oscillcgrams, they are shown in Fig. 111, 112.

Let us examine the dependerces, cbtained with the residue/settling of the irgcts which were established/installed with the lcngitudinal eccentricity 4CC mm to the left from the panel (Fig. 111).

Comparing dependences $h = f(t)$, $h = f(t)$ in Fig. 111e, f with a change in pressure $p = f(t)$ and $p = f(t)$, it is possible tc establish that the beginning of the ccverage cf chckes/throttles occurs, when the pressure differential in the synchronizing cylinders is 7-10 kgf/cm².

System is very sensitive. Virtually the moticn cf throttle valve follows instantly a change cf the pressure in the synchronizing cylinders.

Frcm graphs $p = f(t)$ and $h = f(t)$ Fig. 111c shows that the true eccentricity in the beginning cf upsetting ingots was mixed, i.e., center cf pressure was misaligned nct only in the longitudinal, but alsc in the transverse directicr tc angular wcrking cylinder 2.

Sensing element of system cperates/wears with lcngitudinal misalignment on the order of 0.25 mm [Fig. 111b, $h = f(t)$; Fig. 111c-f, $p = f(t)$].

Upcn reaching of the maximum pressure of step/stage the I in the pitch cylinders maximum value of misalignment is 2.0 mm (0.125 mm/m). At this time the grcup cf cuter wcrking cylinders, where enter angular cylinders, it is nct yet connected, but the mcment/tcrque, created in the synchronizing cylinders, it is insufficient fcr the balancing of cross-beam. Upon the start of outer cylinders the misalignment is decreased, since is choked the fluid flow, which enters cylinders 3, 4. For the stabilization of misalignment it is required by 4-5 s, after which its value is 1 mm (0.06 mm/m).

Upon cascade connection of the II effort/force the value of misalignment is decreased to 0.25 mm (0.015 mm/m), since simultaneously increases the leveling moment/torque from the effort/force in the choked angular working cylinders.

With cascade connection the III longitudinal misalignment was 0.5 mm (0.03 mm/m). In the same period is fixed transverse misalignment 0.5 mm (0.14 mm/m). Let us note that fluctuations of pressure in the working cylinders with t=190-200 s are caused by the short-term translation/conversion of handle of the distributor of working cylinders into the neutral position [Fig. 111b, $H^{p}_{s} = f(t)$]. These oscillations at the moments of switching the valves of brief ones and rapidly attenuate.

From the examination of dependences $S_{пп} = f(t)$ and h [illegible] (Fig. 111a, b) it is evident that during the motion of cross-beam in the period when pressure in the line of working cylinders was established/installed, value $h^{пр}_{ц}$ is constant, which indicates the stability of the work of system.

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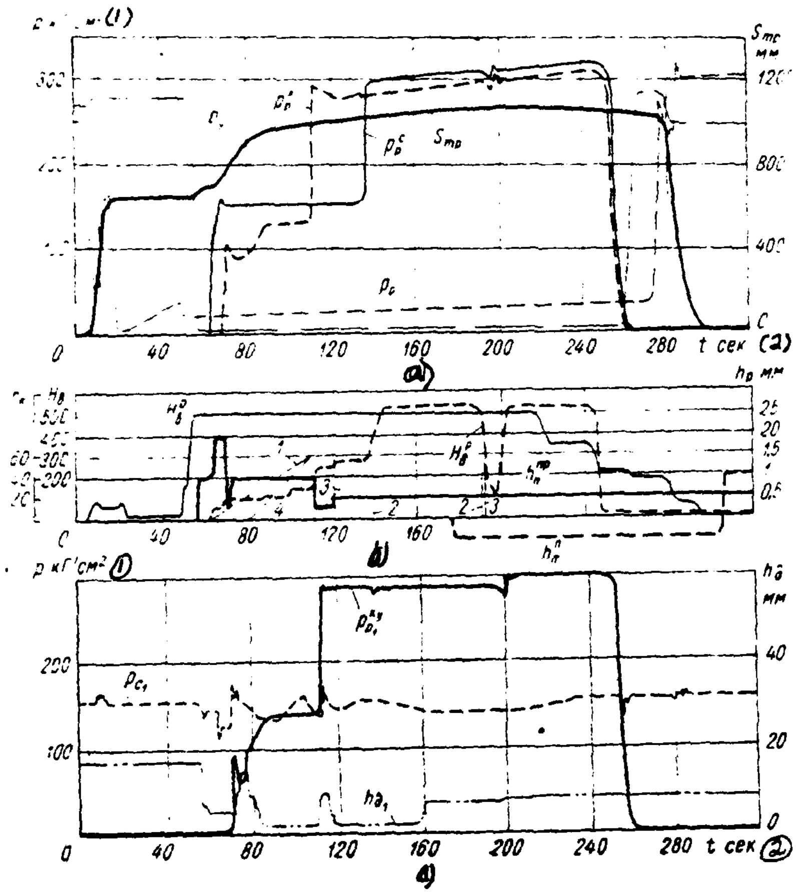

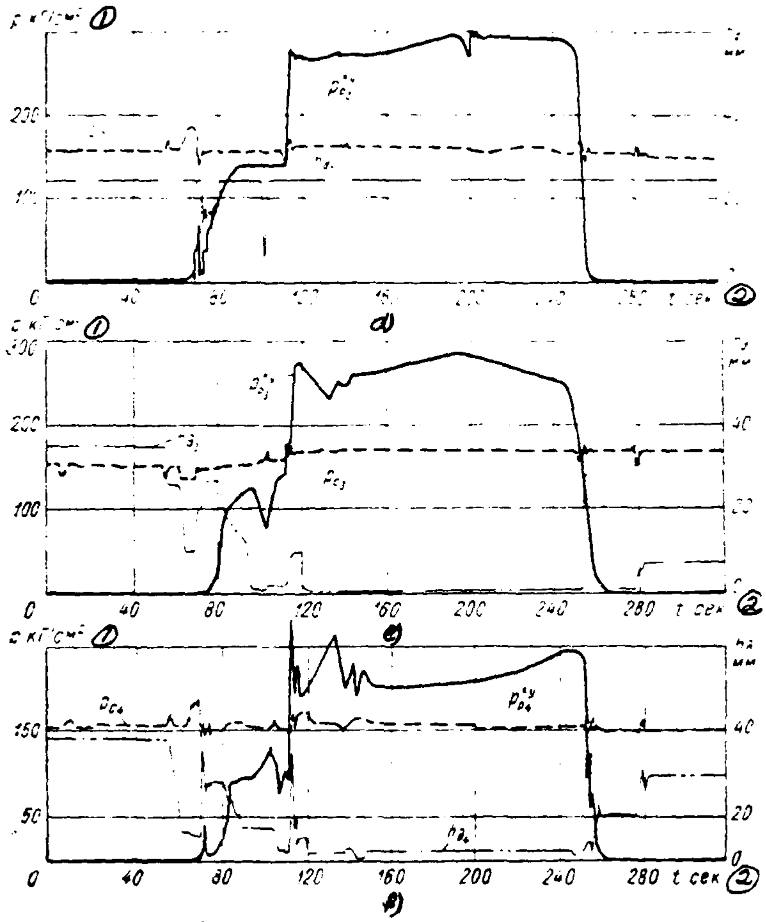

Fig. 111. Parameters, which characterize work of press by effort/force 75000 T at loading with longitudinal eccentricity 400 mm (to the left from control panel). The designations: - pressure in the group of pitch cylinders (dynamometer I); $p_{p_i}^{K}$ - pressure in the group of outer working cylinders (dynamometer II); p_0 - pressure in the reverse/inverse cylinders (dynamometer III); - pressure in the balancing cylinders (dynamometer IV); $p_{p_i}^{Ky}$ $(i = 1; 2; 3; 4)$ - pressure in the angular outer working cylinders after the throttle valve (dynamometer VIII, VII, V, VI); p_{c_i} $(i = 1; 2; 3; 4)$ - pressure in the synchronizing cylinders (dynamometer XII, X, XI, IX); h_{∂_i} $(i = 1; 2; 3; 4)$ - course of the corresponding throttle valves (hodographs 12, 11, 10, 9); S_{mp} - course of the crosshead (traverses) (hodograph 6); h_n^{np} and

h_n^n - longitudinal and transverse misalignments of the crosshead (hodographs 8, 7); H_n^o - course of the rack of the water distributor of working cylinders; H_n^o - course of rack of water distributer of reverse/inverse cylinders; h_k - valve travel of 1-4 water distributors. The designations of dynamometers and course graphs/counts see in Fig. 109.

Key: (1). kgf/cm². (2). s.

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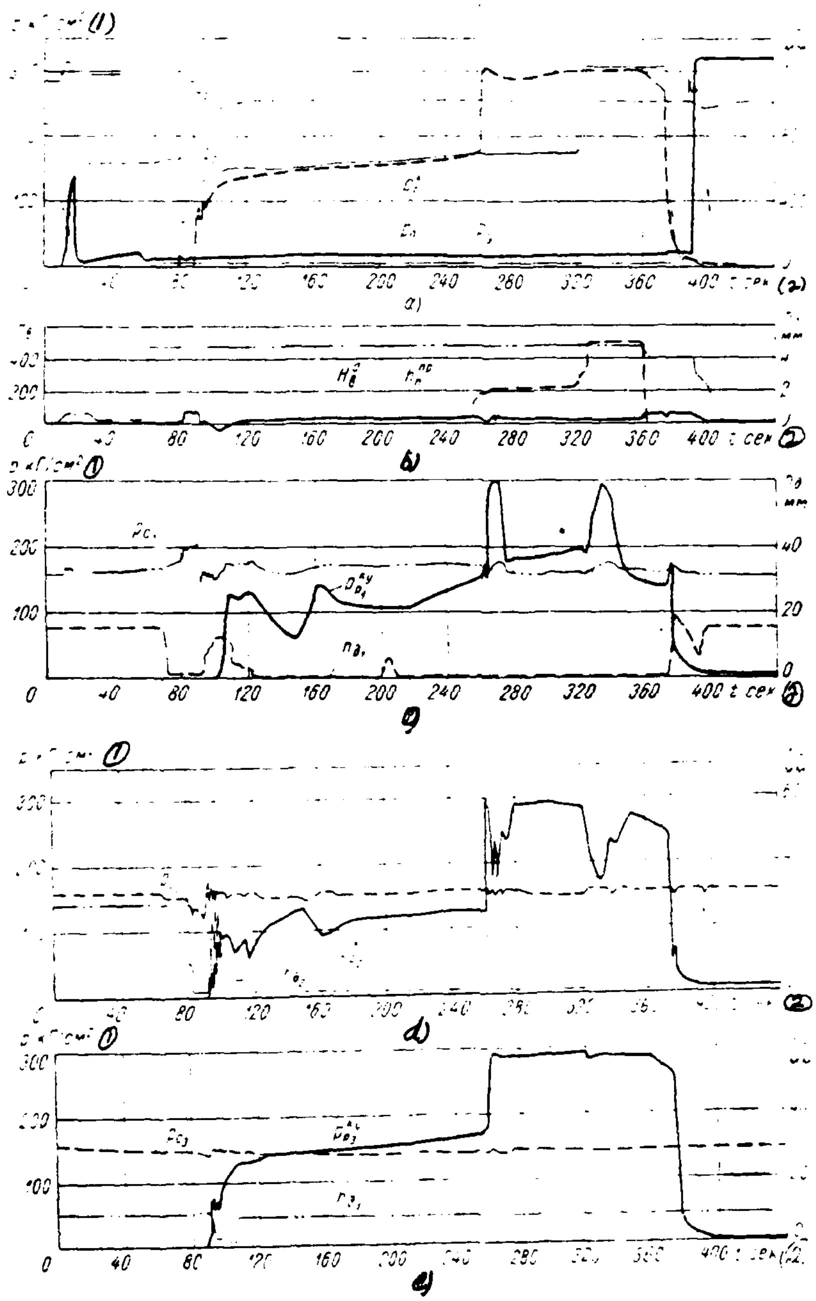
Short-term fluctuations of pressure in the working cylinders, as is shown experiment, also do not cause the angular oscillations of cross-beam as a result of its large inertness.

The basic parameters, which characterize the work of system for the moment/torque when is achieved/reached the maximum effort/force of step/stage III (t=240 s), are given in Table 25.

During the experiment the complete effort/force of press (including the weight of moving elements) was 69975 T.

Judging by the value of voltages in the struts of the average/mean frames of press and in longitudinal cennections/communicaticrs which is fixed with the lcading cf the control equipment in questicn (the vcltages indicated are distributed evenly and are 400-500 kgf/cm²), it is possible to conclude that with the accentricity does nct cccur the additional loading of the frames cf press.

From the analysis cf the graphs, which characterize the work cf system with the residue/settling cf ingots with the lcngitudinal eccentricity 400 mm to the right frcm the control panel (Fig. 112), it is pcssible to arrive virtually at the same conclusions relative to time and sequence cf activaticr cf the organs/ccntrols of system, that alsc with the residue/settlirg with the same eccentricity, but to the left from the parel (see atcve). These graphs alsc ccrfirm the high sensitivity of system. Value h'' did not exceed 1 mm (0.C62 mm/m), moreover it alsc is fixed at the mcment/torque when tc high-pressure lire was ccrnected cnly the group of pitch cylinders. Upcn the start of outer cylinders the misalignmant tecomas equal tc zerc. Further occurs the rotaticn cf the crosshead tc the side, oppcsite the initial misalignmert, cn 0.3 mm.


a)
b)
c)
d)
e)

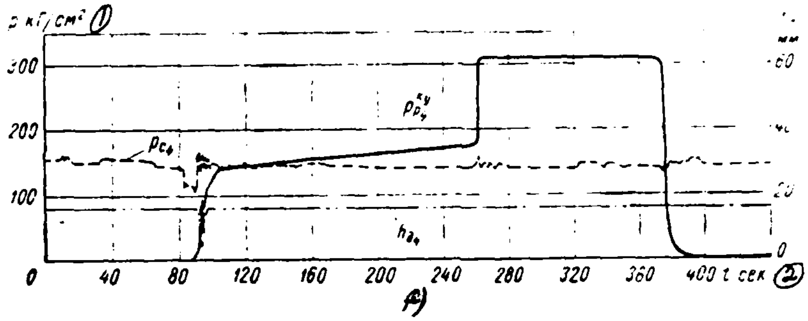


Fig. 112. Parameters, which characterize work by effort/force 75000 T at the loading with the longitudinal eccentricity 400 mm (to the right from the control panel). Designations see in Fig. 111.

Key: (1). kgf/cm². (2). s.

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Then it re-set, stopping with the longitudinal misalignment, equal to 0.3 mm (0.019 mm/m). With the maximum effort/force of step/stage the III longitudinal misalignment reaches 0.6 mm (0.0375 mm/m). During the loading was fixed the transverse misalignment whose maximum value reached 4.4 mm.

The basic parameters of system at the effort/force of step/stage III (t=350 s) are given in Table 26.

As can be seen from Table 26 (for example, in value $p_{p_i}^{\wedge y}$), besides longitudinal there is also transverse excentricity toward removal/distance from the panel.

The complete effort/force of press in this case was 67280 T. Voltages according to the data of supervisory equipment in practice do not differ from those obtained earlier with the longitudinal eccentricity to the left from the control panel. In this case the voltages decreased (to 400-450 kgf/cm²), since the effort/force of press in this case was less.

Let us determine the value of actual eccentricity with the maximum effort/force of press, utilizing data of oscillographing. From the momental equation of forces, which effect on the crosshead, we will obtain that the eccentricity

$$e = \frac{l_1 (P_I - P_{II}) - M_c}{3P_I + P_{II} - G},$$

where l_1=650 - distance from the outer cylinders to the center of press in cm;

P_I =16600 m - effort/force of each of three groups of cylinders, except the group where there are the "Choked" cylinders, in T;

P_{II}= 12750 - effort/force of the group of cylinders, where enter the "Choked" cylinders, in T.

Table 25. Parameters of the leveling system at the end of the working course.

(1) Параметры (рис. 111)	(2) Номер (i) цилиндра и дроссельного клапана			
	1	2	3	4
$p_{p_i}^{\kappa}$ в кГ/см² (3)	290	300	245	240
p_{c_i} в кГ/см²	155	155	170	160
h_{0_i} в мм (4)	8	0	35	28
p_p^c в кГ/см² (3)	—	315	—	—
p_p^{κ} в кГ/см² (3)	—	310	—	—

Key: (1). Parameters (Fig. 111). (2). Number (i) of cylinder and throttle valve. (3). in kgf/cm². (4). in.

Table 26. Parameters of the leveling system at the end of the working stroke.

(1) Параметры (рис. 112)	(2) Номер (i) цилиндра и дроссельного клапана			
	1	2	3	4
$p_{p_i}^{\kappa_y}$ в кГ/см² (3)	150	250	300	300
p_{c_i} в кГ/см²	165	160	150	150
h_{0_i} в мм (4)	15.6	27.6	0	0
p_p^c в кГ/см² (3)	—	305	—	—
p_p^{κ} в кГ/см² (3)	—	305	—	—

Key: (1). Parameters (Fig. 112). (2). Number (i) of cylinder and throttle valve. (3). in kgf/cm². (4). in.

Hence, substituting in the expression for the eccentricity known values, we will obtain

$$e = \frac{650(16\,600 - 12\,750) + 49\,000}{50\,000 - 12\,750 + 5000} = 376 \text{ mm}$$

Consequently, the value of adjusting eccentricity (400 mm) was changed insignificantly.

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Let us determine relative values Δh_u и Δh_c (see Table 29):

$$\Delta h_u^0 = \frac{\Delta \bar{h}_u^{max}}{L}; \quad \Delta h_c^0 = \frac{\Delta \bar{h}_c^{max}}{L},$$

where L - distance between the extreme and central control points.

Being assigned by the values of the average/mean specific efforts/forces, permitted by the strength of press and instrument, and also knowing the actual conditions of loading (P and q) and value Δh_u^0, Δh_c during stamping of control forgings, let us construct for each step/stage of effort/force tentative dependences Δh_u^0 on q (Fig. 119) [18]. On this graph value Δh_u^0 is given in o/o from resultant error, caused by the band of cross-beam and by the warping of die/stamp.

From Fig. 119 it is evident that almost on entire range of the specific efforts/forces used magnitude of error according to the thickness, which depends on the elastic warping of die/stamp, is more than the sum of two errors: from the elastic warping of die/stamp and bend of cross-beams. In the case when specific efforts/forces exceed 30 kg/mm² (during stamping of the forgings of the increased precision/accuracy), to the precision/accuracy of stamping the bend of cross-beams does not have an effect.

Let us examine some from the die-forged forgings, obtained on the press by effort/force 75 000 T (Fig. 120a, b). They are standardized and have relatively larger thickness of fabric (30-60 mm). From each such forging they manufacture several parts of different thickness. These forgings are characterized also by intricate shape, presence of the system of wide edges/fins, by large drops/jumps in the thicknesses. All this impedes the investigation of forgings.

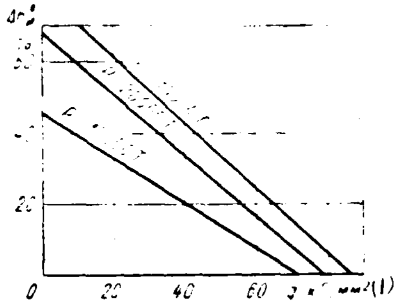

Fig. 119. Tentative dependences, which characterize the rigidity of the cross-beams of press by effort/force 30 000 T of UZTM from the point of view of their effect to the precision/accuracy of stamping.

Key: (1) kg/mm².

Table 30. Data about the control forgings.

(1) Материал штампованной поковки	(2) Усилие штамповки в тыс. T		(5) Площадь проекции в см²	(6) Среднее удельное усилие в кГ/мм²	
	(3) расчетное	(4) фактическое		(3) расчетное	(4) фактическое
В93 (рис. 120, а) (7)	49	44	15 600	31,40	28,20
В93 (рис. 120, б)	49	47	14 600	33,60	32,00

Key: (1). Material of the die-forged forging. (2). Effort/force of stamping in thousand T. (3) calculated. (4) actual. (5). Projected area in cm². (6). Average/mean specific effort/force in kg/mm². (7). Fig.

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Data of the forgings in question are given in table 30.

Let us note that the bottom dies of press by effort/force 75 000 T had permanent deflection (table 31).

The deviation of the size/dimension of the obtained blank from that caused by drawing, connected with the residual shaping of die/stamp, reaches 1.6 mm. However, the depth of the figure of die/stamp for the forging of the type of that shown in Fig. 120a, is lower than provided for by drawing. In this case resultant error must decrease by the value of a "reverse/inverse" error in the die/stamp, i.e., allowed during its manufacture, which was considered during the investigation.

For processing of the results of the measurements of thickness was used the sampling.

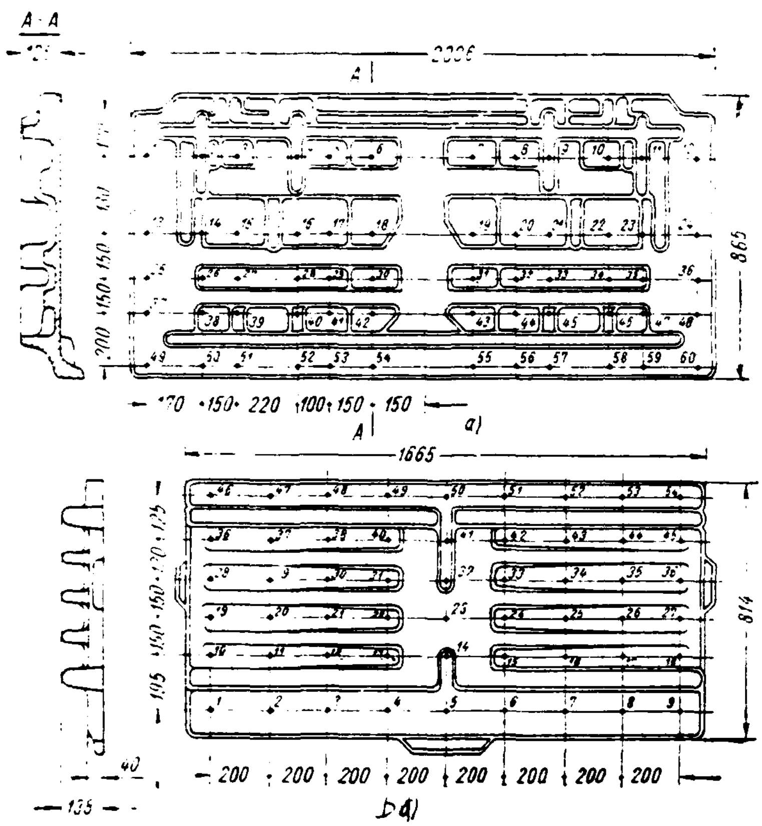

Fig. 120. Die-forged forgings of panels by the size/dimension: a) 2000x850 mm; b) 1670x800 mm.

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Error from the misalignment of the crosshead for the indicated in table 30 forgings is formed due to values Δh_{1}^{n} (there was no misalignment lengthwise). In this case relative values this of error for the forgings indicated coincide. It is possible to assume that the fixed small transverse wedge shape is connected with the nonuniformity of the elastic warping of die/stamp due to the dissymmetry of forgings in the transverse direction.

The results of the error analysis in the geometry of the die-forged forging (Fig. 120b, section/cut 19-27, where it is discovered is maximum lenticularity) are given in Fig. 121.

Maximum resultant error $\bar{\delta}_{max} = 13{,}92$ mm is composed of the following values (in the brackets it is indicated o/o relatively $\bar{\delta}_{max}$):

$$\Delta\bar{h}_{u}^{max} = 0{,}4 \text{ мм } (2{,}5\%);$$
$$\Delta\bar{h}_{c}^{max} = 1{,}32 \text{ мм } (9{,}5\%);$$
$$\Delta h_{ш}^{max} = 1{,}6 \text{ мм } (11{,}5\%);$$
$$\Delta\bar{h}_{m} = 10{,}6 \text{ мм } (76{,}5\%).$$

Let us note that the relationships/ratios of errors from the elastic warping of instrument and from the bend of cross-beams for the forgings, obtained on the press by effort/force 75 000 T, virtually were not changed in comparison with the analogous relationship/ratio of the errors in the forgings, obtained on the press by effort/force 30 000 T.

Table 31. Given deviaticns due to elastic defcrmaticns for scme die-forged fcrgings, cbtained cn the press by effort/force 75 000 T.

(1) Штампованная поковка	(2) $(\Delta h_u + \Delta h_c)^{max}$, мм	$(\Delta h_c + \Delta h_m)^{max}$, мм (2)	$\frac{P_{np}}{P}$	[illegible]	[illegible]	(2) [illegible]	[illegible] (2)
(3) Рис. 120, а	2,2	4,2	1,59	1,41	1,5	7,4	[illegible]
Рис. 120, б	1,72	3,32	1,49	1,25	1,88	6,0	[illegible]

Key: (1). Die-forged forging. (2) ir mm. (3). Fig.

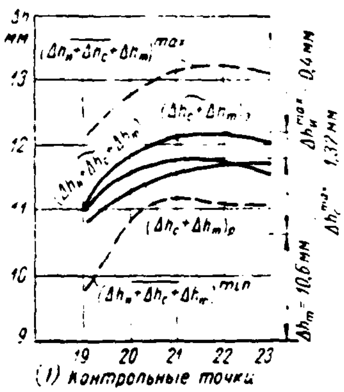

Fig. 121. Distcrtion of gecmetry cf dic-forged forging of panel with size/dimension 1670x800 cf mm ir central longitudinal section.

Key: (1). Control points.

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Taking into account that for the die-forged forging of the type of that shown in Fig. 120a in section/cut 25-36 $\Delta\bar{h}_m$ =11.2 mm, the maximum lenticularity (at point 32) will be 3.2 mm. If the sizes/dimensions of die/stamp were sustained strictly on the drawing, then this value achieved 4.0 mm (at point 32 $\Delta h_{ш}$ =1 mm). Since $\Delta\bar{h}_u^{max}$ = =0.6 mm, and the error, introduced by sowblocks, this forging is in connection with 2.0 mm, the value of the elastic warping of die/stamp is equal to 1.6 mm. Assuming that the systematic error, called by the state of die/stamp, is absent, we will obtain following components of maximum resultant error $\tilde{\delta}_{max}$ =15.4 mm:

$$\Delta\bar{h}_u^{max} = 0{,}6\ мм\ (3{,}8\%);$$
$$\Delta\bar{h}_c^{max} = 1{,}6\ мм\ (10{,}4\%);$$
$$\Delta h_{ш}^{max} = 2{,}0\ мм\ (13\%);$$
$$\Delta\bar{h}_m = 11{,}2\ мм\ (73\%).$$

It is possible to consider that a "reverse/inverse" error in the die/stamp completely compensated deviations from the bend of cross-beam and partially from the elastic warping of die/stamp.

The given deviations for the forgings, similar to those examined, they are shown in table 31. In this case as the standard parameters are accepted the following: $P_{np} = 70\,000\ T$; q_{np} =4000 kgf/cm²; a_{np} =1.5 m.

The greatest deviation of the sizes/dimensions of the standard forging, obtained with the maximum effort/force of press, would be

6-7 mm. Wedge shape of one of the forgings of the type of the panel, not symmetrical in the plan/layout (2700x1400 mm) and obtained on the press by effort/force 75 000 T, is characterized by the following averaged numerals: lengthwise 0.54 and in the transverse direction of 0.63 mm/lin. m. This confirms the high effectiveness of the system of the limitation of misalignment.

After determining relative values Δh_u and Δh_c, let us construct also for the press by effort/force 75 000 T tentative dependences Δh_u^o on q (Fig. 122).

As for the press by effort/force 30 000 T, these dependences show that the elastic bend of cross-beams in comparison with the elastic warping of die/stamp plays insignificant role in the formation of the lenticularity of the die-forged forgings, it is especially with the specific efforts/forces more than 30 kg/mm².

With the conclusions/derivations, obtained for the presses by effort/force 30 000 T UZTM and 75 000 T, coincide the data of the studies of L. A. Shofman and L. D. Gol'man which are carried out for the press with force 30000 T "Sleman" [24].

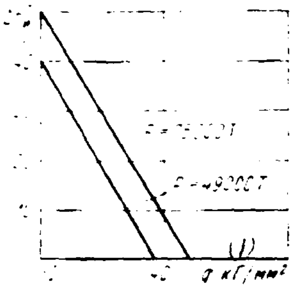

Fig. 122. Tentative dependences, which characterize the rigidity of the cross-beams of press by effort/force 75 000 T from the point of view of their effect to the precision/accuracy of stamping.

Key: (1) kg/mm².

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The task of determining the amount of deflection of the thickness of the die-forged forging due to the elastic bend of cross-beams is reduced to the determination of the warped surface of the latter in the zone, limited by the area of die/stamp. In this case we consider that during the loading the die/stamp with the set of plates/slabs is bent, repeating the form of cross-beam, since its rigidity is immeasurably more than the rigidity of stamp set. As an example let us examine the determination of bent surface of the cross-beam of press by effort/force 75 000 T. The function of saggings/deflections we will approximate by exponential polynomial. As starting data we utilize results of calculating the bending strains of the cross-beam of press by effort/force 75 000 T by the net point method which are sufficiently close to actually measured amounts of deflection. To perform calculations by the method indicated for all required points of the surface of die/stamp is inexpedient. The function of saggings/deflections we find in the form of the polynomial of the 3rd degree which considers torque load and load from the concentrated forces.

Utilizing the method of least squares [7] for selecting the approximating polynomial let us construct it for each of three sections/cuts: 0-4, 5-8, 9-12 (Fig. 127). In this case we accept, that the effort/force of press is equal to 70 000 T. After taking polynomial for section/cut 0-4, let us find saggings/deflections for those points of the longitudinal axis of the forgings, in which were determined the components from the elastic warping (at values of x=0.25 a; 0.5 a; 0.75a; a). Then let us determine [illegible]/deflections at the analogous points of sections/cuts 5'-8 [illegible]. For computing the saggings/deflections let us compose [illegible].

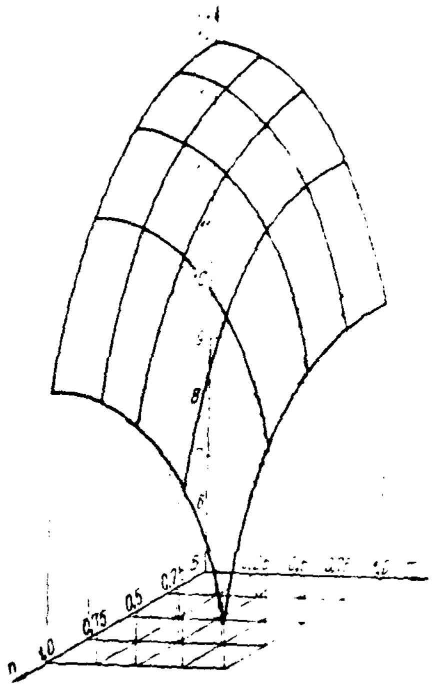

Fig. 125. Surface $\omega_1=f(m, n)$ with $\gamma=1$.

Table 35.

Номер точки (рис. 127) (1)	x^0	x	x^2	x^3	x^4	x^5	x^6
1; 5; 9	1	1,15	1,325	1,525	1,75	2,01	2,31
2, 6, 10	1	3,45	11,9	41,1	142,0	490	1 690
3, 7, 11	1	5,75	33,1	190,0	1095,0	6 300	36 200
4, 8, 12	1	8,05	64,8	522,0	4200,0	33 800	272 000
(2) Итого	4	18.4	111,1	754,6	5438,7	40 610	309 892

(3) Примечание. Расстояние x от центра поперечины по ее продольной оси в м.

Key: (1). Number of point (Fig. 127). (2). Altogether. (3). Note. Distance x from the center of cross-beam along its longitudinal axis m.

Table 36.

Номер точки (рис. 127) (1)	y	xy	x^2y	x^3y
1	6,8146	7,84	9,05	10,4
2	5,3939	18,6	64,1	222,0
3	3,1677	18,2	105,0	602,0
4	0,9315	7,5	60,4	486,0
Bi	16,3077	52,14	238,5	1320,0
5	6,5779	7,55	8,7	10,05
6	5,2356	18,0	62,2	215,0
7	3,0353	17,4	100,5	575,0
8	0,6947	5,57	44,8	362,0
Bi	15,5435	48,52	216,2	1162,05
9	5,9774	6,86	7,9	9,1
10	4,8512	16,8	57,8	200,0
11	2,7144	15,6	9,0	515,0
12	0	0	0	0
Bi	13,543	39,26	155,7	724,1

(2) Примечание. Величина прогиба y в мм, а расстояние x от центра поперечины по ее продольной оси в м.

Key: (1). Number of point (Fig. 127). (2). Note. Amount of deflection y in mm, and distance x from the center of cross-beam along its longitudinal axis m.

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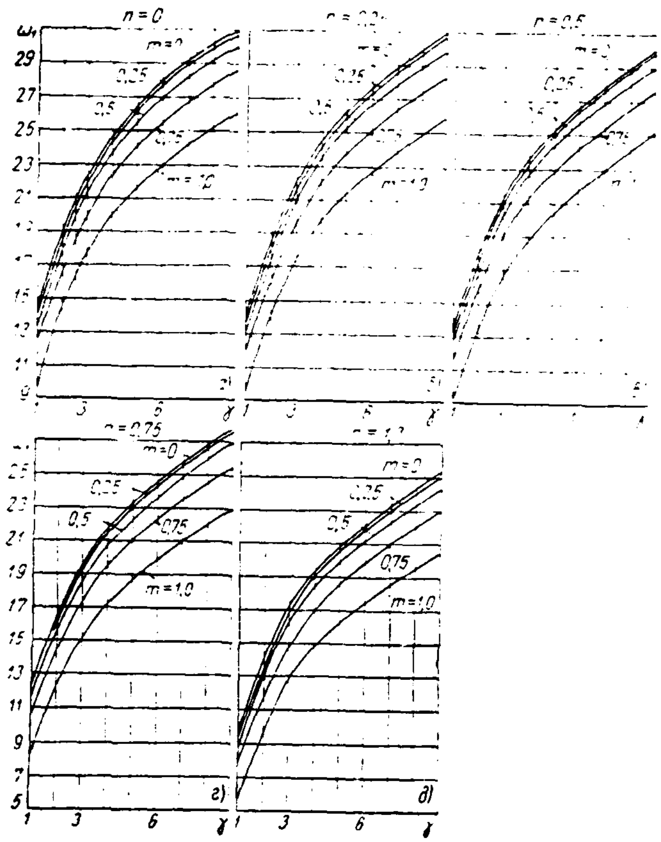

Fig. 126. Dependences $\omega_1=f(\gamma)$: a) with n=0; b) with n=0.25; c) with n=0.5; d) with n=0.75; e) with r=1.C.

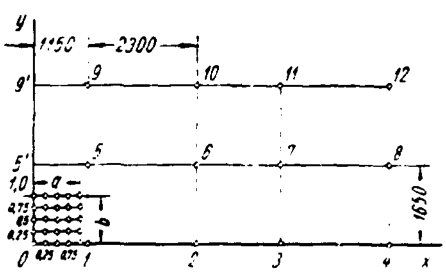

Fig. 127. Referance grid cf cross-beam of press by effort/forc? 75

000 T.

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During the computation for the method of least squares the system of equations takes the form:

$$\left.\begin{aligned} b_0a_0 + b_1a_1 + b_2a_2 + b_3a_3 &= B_1; \\ b_1a_0 + b_2a_1 + b_3a_2 + b_4a_3 &= B_2; \\ b_2a_0 + b_3a_1 + b_4a_2 + b_5a_3 &= B_3; \\ b_3a_0 + b_4a_1 + b_5a_2 + b_6a_3 &= B_4. \end{aligned}\right\} \quad (99)$$

In this case $b_i = \sum_k^{k=3} x_k^i; \; B_i = \sum_k^{k=3} x_k^{i-1} y_k; \; k = 1, 5, 9.$

Solving the obtained three (according to a number of the sections/cuts of cross-beams in question) systems of equations [each system of the type of equations (99)], that are distinguished only by absolute terms, we will obtain the values of the unknown coefficients (table 37).

Let us find the error in the computation, obtained during the calculation via approximation, and let us compare it with the calculation according to the net point method:

$$\varepsilon = y - \bar{y},$$

where y - the original value of sagging/deflection, obtained by the net point method (table 38); $\bar{y}$ - value of sagging/deflection found from the approximating polynomial.

In terms of values ε for the appropriate polynomials it is possible to make a conclusion about the fact that the approximation conducted is satisfactory. Then saggings/deflections in the longitudinal sections we find from the following equations: for section/cut 0-4

$$y = 7,65037 - 0,6696x + 0,000371x^2 - 0,002665x^3;$$

for section/cut 5'-8

$$y = 7,43453 - 0,65809x + 0,002125x^2 - 0,0030825x^3;$$

for section/cut 9'-12

$$y = 6,53322 - 0,45716x + 0,000357x^2 - 0,005596x^3.$$

Table 37. Values of the unknown coefficients.

(1) Сечение (рис. 127)	(2) Коэффициенты			
	a_0	a_1	a_2	a_3
0—4	7,65037	—0,6696	0,000371	—0,002665
5—8	7,43453	—0,65809	0,002125	—0,0030825
9—12	6,53322	—0,45716	0,000357	—0,005596

Key: (1). Section/cut (Fig. 127). (2). Coefficients.

Table 38. Comparison of the errors, obtained during the calculation via approximations and by the net point method.

(1) x в м	(2) Номер точки (рис. 127)	$\bar{y}$ в мм	y в мм	ε в %
1,15	1	6,87676	6,8146	−0,06216
	5	6,77586	6,5779	0,19796
	9	5,99945	5,9774	−0,02205
3,45	2	5,2353	5,3939	—0,1586
	6	5,0628	5,2356	—0,1728
	10	4,73057	4,8512	—0,1206
5,75	3	3,3009	3,1677	−0,1332
	7	3,1347	3,0353	0,0994
	11	2,8526	2,7144	−0,1382
8,05	4	0,8924	0,9315	—0,0391
	8	0,6667	0,6947	—0,028
	12	—0,04265	0	—0,04265

Key: (1) in. (2). Number of point (Fig. 127).

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If we by analogy with preceding/previous approximate bend curve for central cross section (0-9), then let us see, that with the transverse sizes/dimensions of the die-forged forging, close to 1 m, the lenticularity (convexity) from the bend of cross-beam in the transverse direction virtually is absent, and it can be disregarded/neglected. Therefore as the basic calculated dependence for determining the composing convexity forging on the elastic bend of cross-beams we utilize an equation for section/cut 0-4:

$$y = 7{,}65037 - 0{,}6696x + 0{,}000371x^2 - 0{,}002665x^3. \quad (100)$$

In order to obtain the component of bend for other steps/stages of the effort/force of press, it is necessary to decrease its value, found from equation (100), it is proportional to a change in the effort/force.

The correction of the figure of die/stamp (shaping) accomplishes/realizes differently in the dependence on the construction/design of stamp sets, the available in the presence stock of machine tools in operation for manufacturing of dies/stamps, etc. The profile/airfoil of die/stamp can be fulfilled either on its worker or on bearing surfaces. It is possible also between the die/stamp and the sowblock to establish/install the special plate/slab, by one of contact surfaces of which is given necessary convexity.

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In the opinion of the authors of this book, it is expedient to accomplish/realize a correction of the working surface of die/stamp, especially because in this case the manufacture of profile/airfoil is combined with the manufacture of impression. It is necessary to note that the convexity, attached to impression, contributes to the best shaping of part.

For the experimental check of the procedure of shaping presented on the press effort/force 75 000 T tested several dies/stamps to working surfaces of which was attached the convex form, determined by calculation. The overall dimensions of each of the forgings (length more than 3 m) to be stamped were such, that the specific effort/force of stamping was approximately 40 kg/mm². The die-forged forgings (Fig. 128) had in essence transverse, but also longitudinal ribbing, moreover on the one hand it solid, with another - partial (it is concentrated in the center section). It is necessary to again emphasize that since in this case was not placed with target obtaining thin fabric, while it was necessary to only remove the lenticularity of forgings and to establish/install the possibility of a precise reproduction of the prescribed/assigned profile/airfoil and its service life during the operation of die/stamp, forging had comparatively large thickness fabrics (to 20-25 mm).

Dies/stamps were manufactured from steel 5KhNV and they were subjected to hardening to the hardness of the working surface HRC=45-46.

Before die setting to the press were inspected their working and bearing surfaces, and is also fixed the state of sowblocks. In this case it turned out that in essence the prescribed/assigned profiles/airfoils were made satisfactorily (Fig. 129). Only in certain cases the height/altitude of the made profile/airfoil proved to be less than the calculated, but not more than 15o/o.

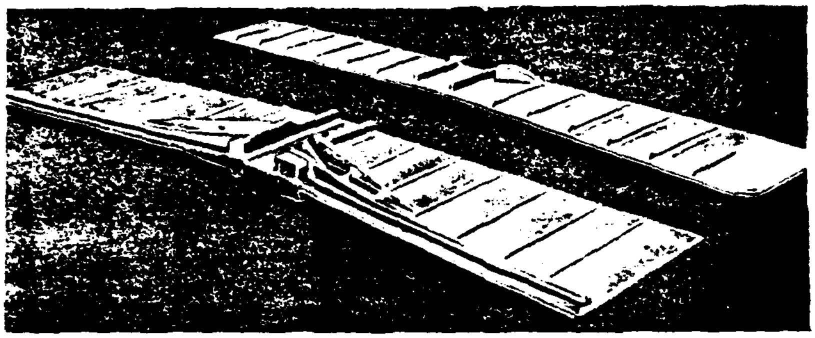

Fig. 128. Die-forged forgings of panels, obtained in the shaped die/stamp.

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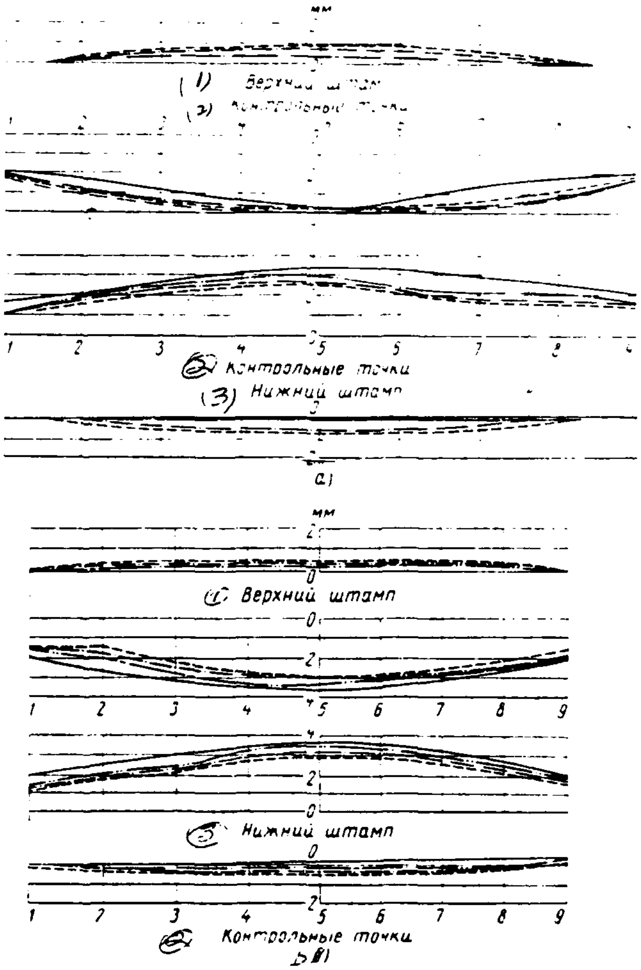

Fig. 129. Supporting/reference and worker of surface of shaped die/stamp (in central longitudinal section): a and b - respectively for forgings with overall dimensions in plan/layout 3200x700 mm and 2700x530 mm. The profile/airfoil: —— - given; -••- - after sinking of die; -•- - after the testing of die/stamp; --- - after

experimental stamping.

Key: (1). The upper die. (2). Control points. (3). Bottom die.

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Were discovered essential deviations from the flatness of the contact surfaces of sowblocks (especially lower), which are the consequence of the elastoplastic bend.

The picture of the loading of the dies/stamps, which do not have residual deformation, and the die base-plates, which accumulated this deformation, can be presented as follows. Simultaneously with the process of the plastic deformation of blank occurs the bend of die/stamp in the direction of the concavity of the contacting with it surfaces of sowblocks. The joining of upper and bottom dies on the angles, and sometimes also on the transverse faces causes the bend of dies/stamps in the opposite direction, which leads to certain straightening of sowblocks (in comparison with the position, occupied by them to the loading). As a result the dies/stamps and sowblocks occupy the intermediate position meanwhile which inherent in the plastically deformed unloaded plates/slabs, and those, which is engaged plates/slabs, after assuming the form of the warped surface of cross-beam.

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VOLUME STAMPING ON HYDRAULIC PRESSES (SELECTED PORTIONS),(U)
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Stamping was accomplished/realized into two transitions/transfers, moreover preparing die/stamp did not undergo correction. The maximum lenticularity of the blanks of those obtained in this die/stamp, was 5.3-5.6 mm.

Consequently, the final, shaped die/stamp entered blanks with the large variation in thickness, which was the consequence of the elastic and residual deformations of stamp set.

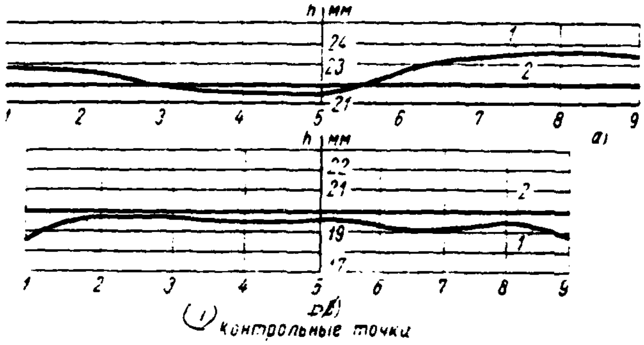

Fig. 130. Deviations from the minimum thickness of fabric in the central longitudinal section of two die-forged forgings, manufactured in the shaped dies/stamps: a) forging 3200x700 mm; b) forging 2700x530 mm; 1, 2 - respectively measured and calculated thicknesses h.

Key: (1). Control points.

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Loading in the final die/stamp was continued not more than 40 s. The obtained forgings virtually did not have a lenticularity. Deviations from the minimum thickness of fabric on the average in the forgings of all typical dimensions did not exceed 1.5-2.0 mm (Fig. 130a), but in the forgings of some typical dimensions 1 mm (Fig. 130b).

The duration of the application of force accepted virtually ensured the constancy of the profile/airfoil of die/stamp in the limits of stamping batch of 20-25 die-forged forgings (see Fig. 129).

As it was shown earlier, dies/stamps work under conditions of low-cycle fatigue. Therefore it is possible to confirm that the constancy of the modes/conditions of loading eliminates the plastic deformations of profile/airfoil, at least, in the limits of manufacture on the powerful/thick presses of forgings of one and the same typical dimension.


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