June 5, 1956 B. F. FAY 2,748,424

ROTARY PELLETING PRESS MODIFICATION

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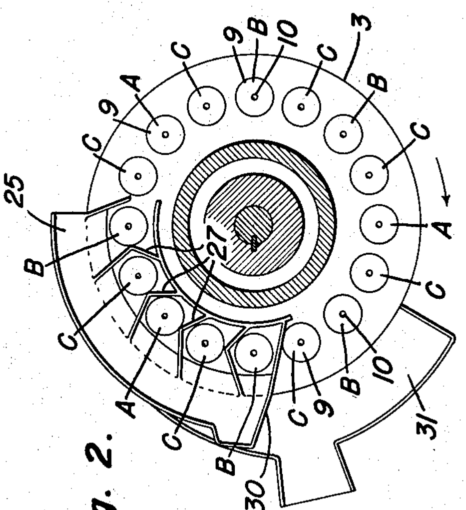

Fig. 2.

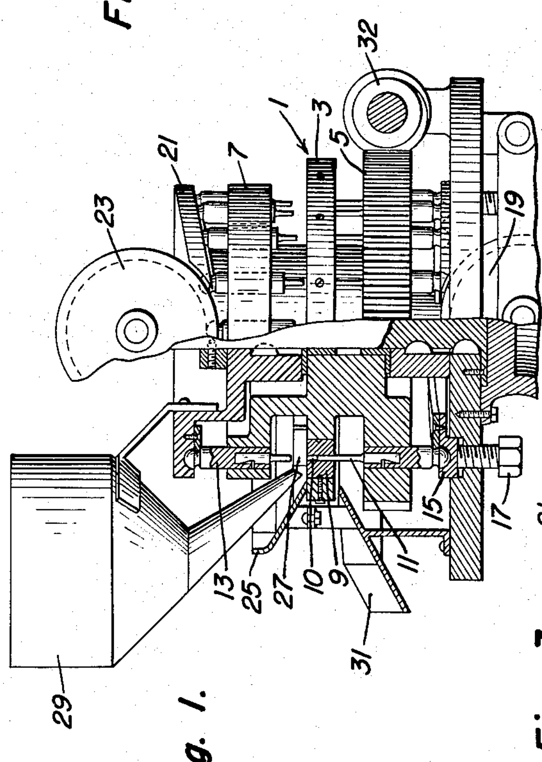

Fig. 1.

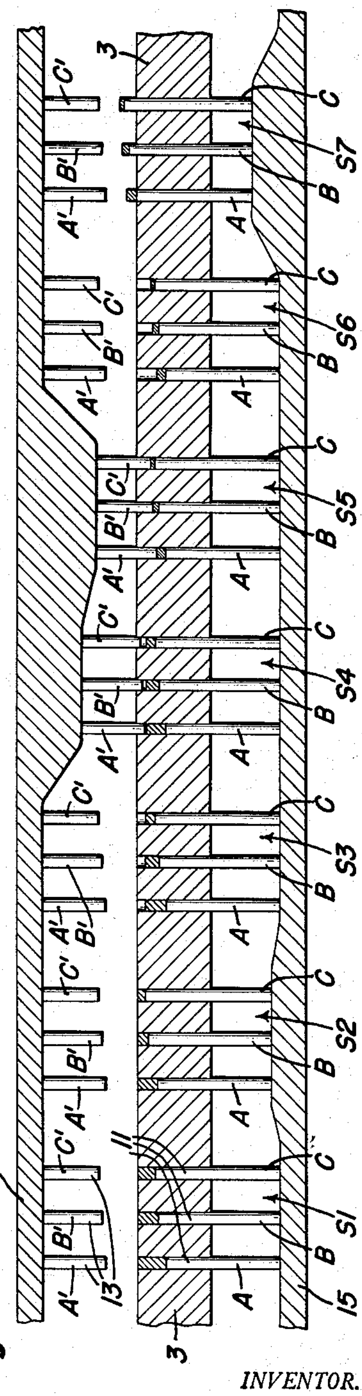

Fig. 3.

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ROTARY PELLETING PRESS MODIFICATION

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4 Claims. (Cl. 18—20)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purpose without the payment to me of any royalty thereon.

This invention relates to a modification of a known type of pelleting press which is adapted to continuously produce pellets of mixed sizes but uniform density.

Continuous pelleting presses are well known in the art. Among them are presses of the general type shown in Patent No. 1,289,570 to Stokes, and Patent No. 901,937 to Scott. Machines following, in general, the Stokes patent are sold under the name "Stokes" Rotary Tablet Machine. Other machines following, in general, the Scott patent are sold as the "Colton" Rotary Tablet Press.

These machines comprise a rotary table in which is mounted an annular series of dies each having a vertical bore. A lower punch is mounted in each die and an upper punch is positioned above and in alignment with the bore. Each die, together with its cooperating upper and lower punches, is termed a "station." As the table rotates the punches are moved through a cycle of operation by stationary cams mounted on the machine frame. A feeder supplies material to the top of the table at the proper point. At this point the lower punches are in a lower position. The upper punches then enter the die and the powder is compressed. (The cam surfaces at the compression stage are formed of rollers rotating on fixed axes.) The upper punch is then withdrawn and the lower punch rises, ejecting the pellet. The presses of the Stokes and Scott patents differ in details, particularly in the position of the cams controlling the upper punches, but the mode of operation is the same in both cases.

These known types of presses produce pellets of uniform size and density. For some purposes, however, it is desirable to obtain a mixture of pellets of the same density but different size. Certain pellets are of such character that they must be given a very minimum of handling and cannot be satisfactorily blended. I have founded that by employing punches of different lengths, correlated in a manner which will be discussed later, pellets can be produced which are of uniform density and accurately sized but which are of mixed sizes so intermingled as to require no further blending to produce a uniform mixture.

For convenience, the detailed description will be based on a machine of the type shown in Stokes' Patent No. 1,289,570.

In the drawing, Figure 1 is a side view, partly in section, showing the essential parts of the pelleting press.

Figure 2 is a plan view, somewhat schematic in character, of the rotary table, feed frame, and take-off tray.

Figure 3 is a diagrammatic view showing the relative lengths of the various punches and the cycle of operations.

The heart of the machine is a rotary head **1**. This head comprises a table **3**, a combined worm gear and lower

punch carrier **5** and an upper punch carrier **7**. Mounted in the table **3** is an annular series of dies **9** having bores **10** of uniform size. A punch **11** is slidably mounted within each bore. Upper punches **13** are aligned with the bores **10** and enter the bores at certain stages of the operating cycle. A lower cam **15**, provided with adjusting screws **17**, controls the position of the lower punches. Lower roller **19** is so positioned as to form part of the lower cam surface at the point where pressure is exerted on the powder to from the tablet. Upper cam **21** controls the upper punches and upper roller **23** cooperates with lower roller **19** at the compression stage.

A feed frame **25** provided with leveler bars **27** distributes powder to the bores **10**. A feed hopper **29** supplies the powder to the feed frame. Finished tablets are diverted by scraper **30** into take-off tray **31**. A worm **32** drives the table in the direction shown in Figure 2.

The apparatus as thus far described is conventional and constitutes the setting for the modification constituting my invention.

In the conventional machines, the lower punches **11** are of uniform length and the same is true of upper punches **13**. The tablets produced are of uniform size and density. By employing punches of different and correlated lengths, I produce tablets which are of uniform density but different size.

Reference should now be made to Fig. 3 which is a diagrammatic drawing showing the relationship of the lengths of the punches and the cycle of operations. In this figure, A and A′ represent a lower and upper punch cooperating to produce a pellet of maximum height, B, B′ a pair producing a pellet of intermediate height, and C, C′ a pair producing a pellet of minimum height. It will be noted that punches A, B, C, are progressively longer while punches A′, B′, C′ are progressively shorter. The precise relationship of the lengths will be discussed later.

The various stages of the operating cycle are shown at S1, S2, etc. In this figure the pairs of punches A, A′, B, B′, C, C′, are shown as if all three pairs occupied each stage simultaneously.

At S1 the punches are shown in the "overfill position," the bore above each punch being filled with powder and the amount of powder in the bore being greater than the amount required to form the pellet. At S2 the lower punches have been raised to the "filling position" and the bores now contain the desired amount of powder, the excess being removed by leveler bars **27**. This pair of steps serves to produce uniform bulk density of the powder in the bores. The distance from the top of the bore to the top of the lower punch at this stage will be termed the "fill depth."

At S3 the lower punches have again been lowered, so that the upper punches may be within the bore during the entire compression stroke. At S4 the upper punches are positioned within the bore at the beginning of the compression stroke. The position at the end of the compression stroke is shown at S5. (Between S4 and S5 rollers **19** and **23** form the surfaces of cams **15** and **21**, respectively.) The distance between the punches at this stage determines the thickness, or height, of the pellet. It will be termed the "pellet height." The ratio of the "fill depth" at S2 to the "pellet height" will be termed the "compression ratio" which is also the ratio of the density of the pellet to the bulk density of the powder in the bore.

At S6 the upper punches have been withdrawn from the bores and at S7 the lower punches have moved upwardly to eject the pellets, which are then removed by scraper **30**. The scraper is so formed, e. g., of spring steel, as to permit the passage of punches B and C which, it will be noted project above the table at this stage. This completes the cycle.

The correlation of the lengths of the punches will now be discussed. (Actually only differences in length are involved, the total length being immaterial.) As noted above, the pellets are to be of substantially constant density and the method of filling the bores produces substantially constant bulk density therein. It is therefore required that the compression ratio (defined above) be substantially the same for each pair of punches.

To effect this requirement, the relationship of the lower punches A and B is given by the equation:

$$LB-LA=K(hA-hB) \qquad (1)$$

and the relative length of the corresponding upper punches A′ or B′ is given by:

$$LA'-LB'=K(hA-hB)-(hA-hB) \qquad (2)$$

where hA and hB are the pellet heights to be produced by punches A—A′ and B—B′, respectively, LA, LA′, LB, LB′, are the lengths of punches A, A′, B and B′, respectively, and K is the compression ratio.

Equation $LB-LA=K(hA-hB)$ expresses the fact that if, for example, punches A are taken as a standard, punch B must be greater in length by an amount equal to the differences in fill depth at **S2** necessary to produce the desired difference in pellet height at S5. (Exactly the same applies to punch C.) For example, assume that punches A—A′ are to produce a pellet height of 3.0 mm., B—B′ one of 1.8 mm. and C—C′ one of 1.3 mm. Also assume that the pellet is to have a density twice the bulk density of the powder. Punch B must then be 2.4 mm. longer than punch A while punch C must be 3.4 mm. longer than punch A.

Equation $LA'—LB'=K(hA-hB)$ is based on the fact that the differences in length between any two upper punches is equal to the difference between their depths of penetration into their respective bores at S5. If punch A were at the position shown at **S2** the penetration of punch A′ would be equal to the difference between the fill depth and the tablet height or $KhA-hA$. Since, however, the lower punches have been moved downwardly at **S3** a distance which may be termed "D," the penetration of punch A′ will be $KhA-hA+D$. Similarly that of punch B′ will be $KhB-hB+D$. The differences between the lengths of punches A′ and B′ is, then,

$$LA'-LB'=(KhA-hA+D)-(KhB-hB+D)=(KhA-KhB)-(hA-hB)$$

or

$$LA'-LB'=K(hA-hB)-(hA-hB) \qquad (2)$$

The equations given above will, of course, apply to any two sets of punches. The values of, for example $LC-LA$ or $LC-LB$ may be calculated in exactly the same manner.

Example 1

It was desired to produce pellets of a given material having a density of 7.5 grm./cc. in three lengths, 3.0 mm., 1.8 mm., and 1.3 mm. A commercial pelleting press of the type described above was adjusted by experiment until pellets of 3.0 mm. length and 7.5 grm./cc. were obtained. The powder was then removed and the fill depth (stage **S2**) measured with a depth micrometer. The depth was found to be 6.15 mm. Thus, compression ratio

$$K=\frac{6.15}{3.0}=2.05$$

The difference in length of the punches may now be computed employing Equations 1 and 2 given above.

The computations are as follows:

$K=2.05$
$hA=3.0$ mm.
$hB=1.8$ mm.
$hC=1.3$ mm.
$LC-LB=2.05\ (1.8-1.3)=1.02$ mm.
$LC-LA=2.05\ (3.0-1.3)=3.48$ mm.
$LA'-LB'=2.05\ (3.0-1.8)-(3.0-1.08)=1.26$ mm.
$LA'-LC'=2.05\ (3.0-1.3)-(3.0-1.3)=1.78$

If preferred, or as a check, the differences in punch length can be determined by more extended experiment rather than by use of the equations given above, making use of the general principle that the difference in length between the two lower punches is equal to the difference in fill depth and that the difference in length between any two of the upper punches is equal to the difference between the values obtained by subtracting the pellet height from its corresponding fill depth. This will be illustrated in the following example.

Example 2

In the operation referred to in Example 1, the machine was adjusted by experiment until pellets of exactly 1.3 mm. length and 7.5 grm./cc. density were produced. The powder was removed and the exact fill depth (stage **S2**) measured with a depth micrometer. The same procedure was duplicated for each of the other pellet heights. The results obtained were as follows:

Punches	Pellet Height (mm.)	Fill Depth (mm.)	Fill Depth Minus Pellet Height (mm.)
A—A′	3.0	6.15	3.15
B—B′	1.8	3.68	1.88
C—C′	1.3	2.67	1.37

For the lower punches, the differences in length are:

$LC-LB=3.68-2.67=1.01$ mm.
$LC-LA=6.15-2.67=3.48$ mm.
$LA'-LB'=3.15-1.88=1.27$ mm.
$LA'-LC'=3.15-1.37=1.78$ mm.

It will be noted that two of the values obtained by this method are identical with those obtained by the equations in Example 1. The other two values differ by only .01 mm (.0004 in.).

Punches of the proper size were then made and mounted on the machine. When the machine was started and adjusted good pellets within the required density and of the three specified sizes were produced simultaneously. It was necessary to make only the same adjustments as if only one size pellet were being produced.

In order that the pellets delivered by the machine may be well mixed, the punches of different size should alternate about the machine. In the operation of Example 2, it was desired that approximately equal weights of the three sizes of pellets should be produced. The 16 station table was therefore provided with punches arranged to produce at each revolution eight 1.3 mm. pellets, five 1.8 mm. pellets and three 3.0 mm. pellets. The distribution of the various pellets is shown in Fig. 2.

While I have described my invention with reference to a machine of the type shown in Stokes Patent No. 1,289,570, I wish to emphasize that it is equally applicable to that of Scott Patent No. 901,937, or any other machine operating on the same principle. It will also be obvious that various other changes may be made without departing from the principles of my inventoin. In particular, the number of different sizes that may be produced is limited only by the number of stations on the machine, the 16 station machine being capable of producing up to 16 different sizes of pellets. The range of sizes produced at one time may be as great as the range which may be produced by adjustment of the unmodified machine.

I, therefore, desire my invention to be limited only by the scope of the appended claims.

I claim:

1. In a pelleting press comprising a rotary table, means for rotating said table, an annular series of dies mounted

in said table, each of said dies comprising a vertical bore, a lower punch mounted for vertical reciprocation in said bore, a series of upper punches carried by said table, each of said upper punches being mounted for vertical reciprocation into and out of one of said bores, first cam means carried by said press and successively engaging each of said lower punches, second cam means carried by said press successively engaging each of said upper punches, feed means arranged to fill said bores with powder to be compressed, said cams being so constructed and arranged as to cause each pair of corresponding lower and upper punches to move through an identical series of operations in which the said lower punch is moved downwardly to a filling position, the bore is filled with powder, the corresponding upper punch is pressed downwardly into said bore compressing said powder forming a tablet and then withdrawn, and the lower punch is moved upwardly, ejecting the tablet from the bore; the improvement wherein the punches of different corresponding pairs are of different lengths, said lengths being so selected that the tablets produced have substantially the same densities but different heights.

2. A pelleting press as defined in claim 1 wherein the lengths of the punches are so related that

$$LB-LA=K(hA-hB)$$

and

$$LA'-LB'=K(hA-hB)-(hA-hB)$$

where hA and hB are the desired heights of tablets of greater and lesser height, respectively, LA and LA′ are the lengths of the lower and upper punches respectively, cooperating to produce a tablet of height hA, LB and LB′ are the lengths of the lower and upper punches respectively, cooperating to produce a tablet of height hB and K is the compression ratio.

3. A pelleting press as defined in claim 1 wherein punches of different lengths alternate around said table.

4. A pelleting press as defined in claim 2 wherein punches of different lengths alternate around said table.

References Cited in the file of this patent

UNITED STATES PATENTS

785,402	Buckley	Mar. 21, 1905
839,157	Kliewer	Dec. 25, 1906

FOREIGN PATENTS

624,773	Great Britain	June 16, 1949