Sept. 20, 1960 G. DE CHANGY 2,953,301

TRANSFER SYSTEM FOR CALCULATING MACHINE

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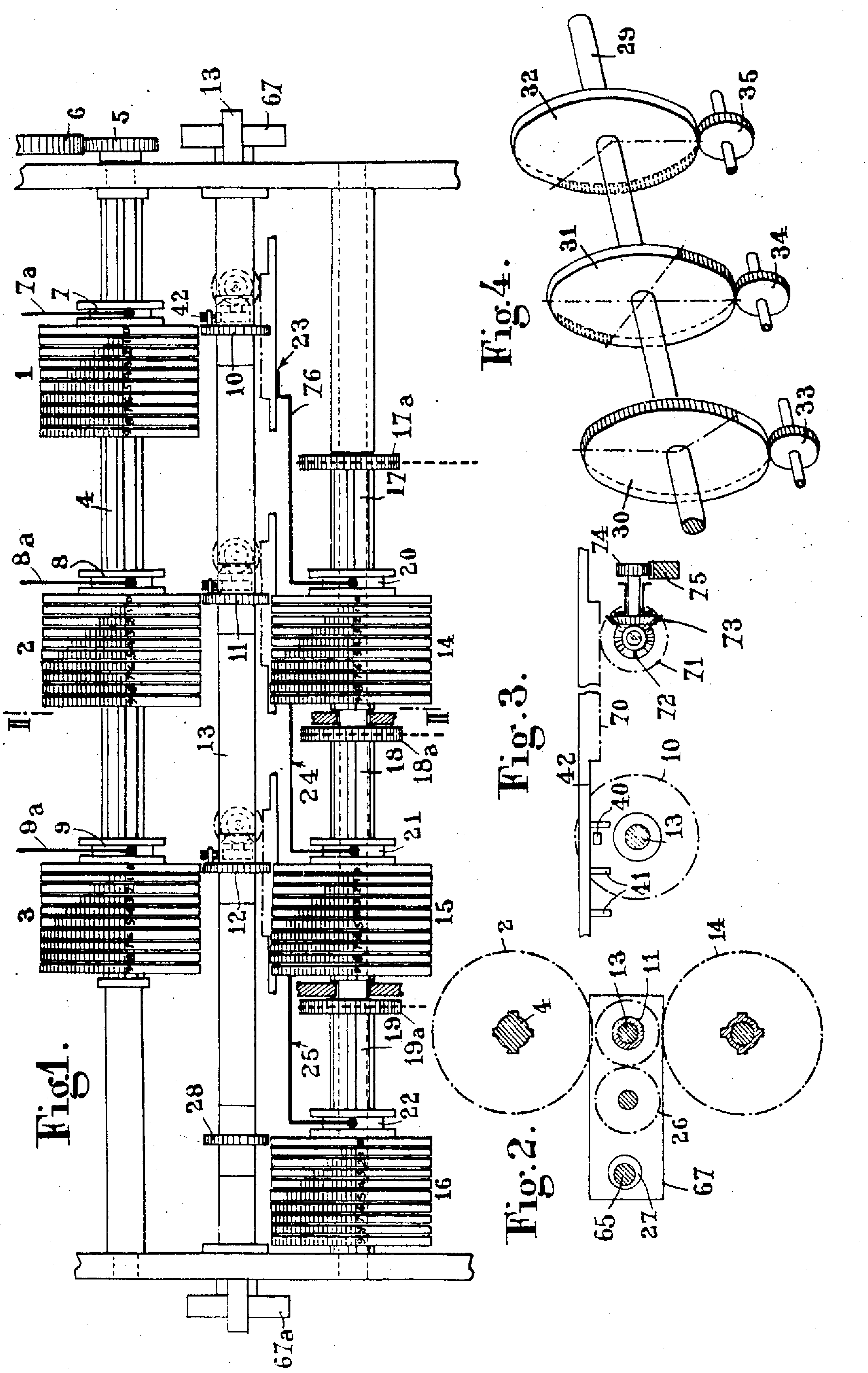


Fig.1. Fig.2. Fig.3. Fig.4.

Fig. 5.

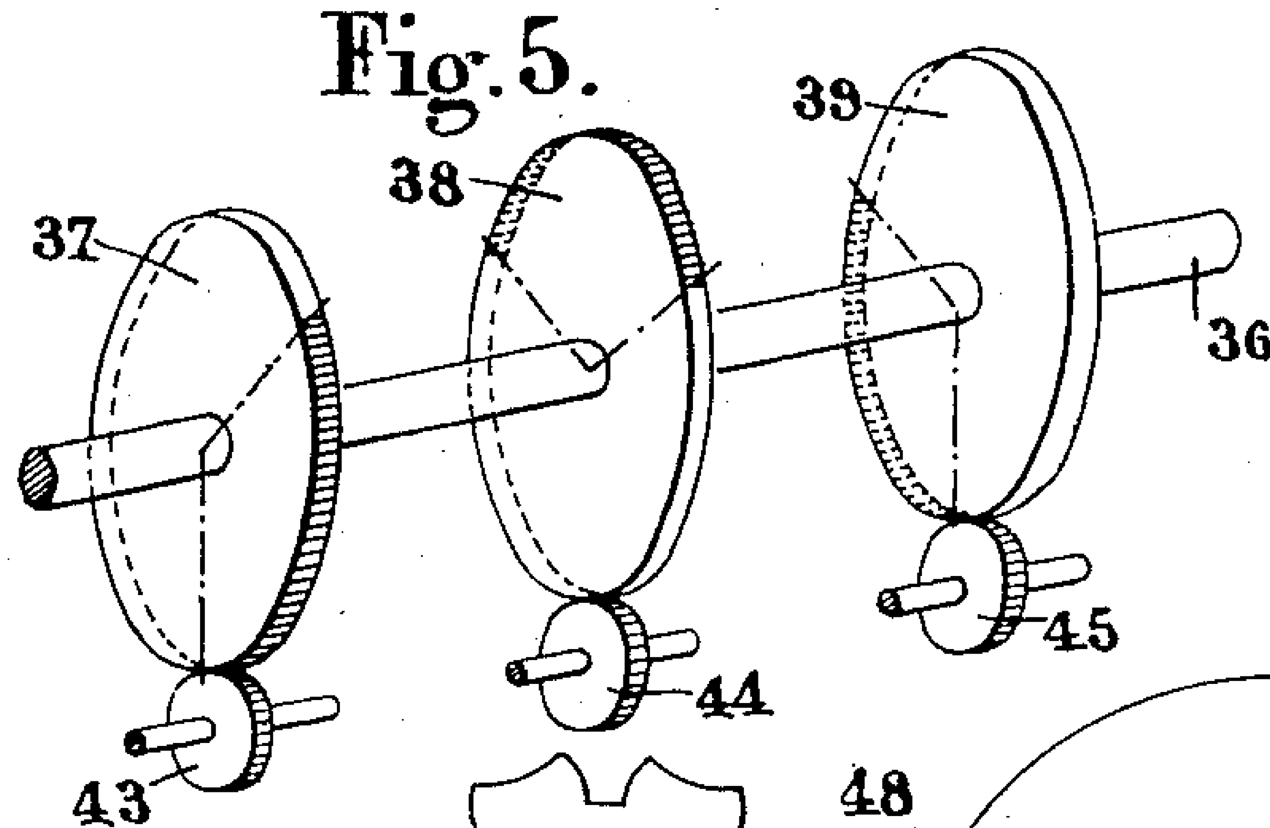
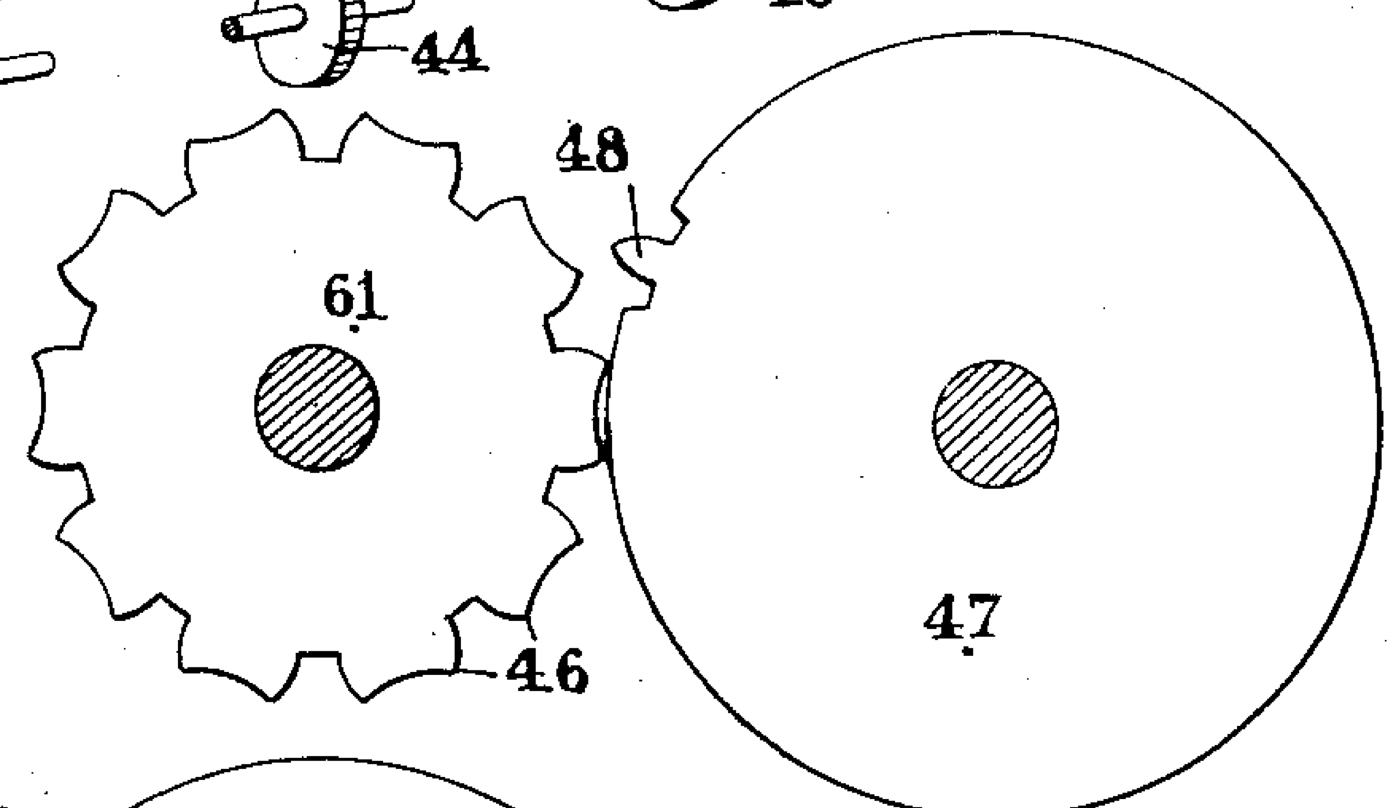


Fig. 6.



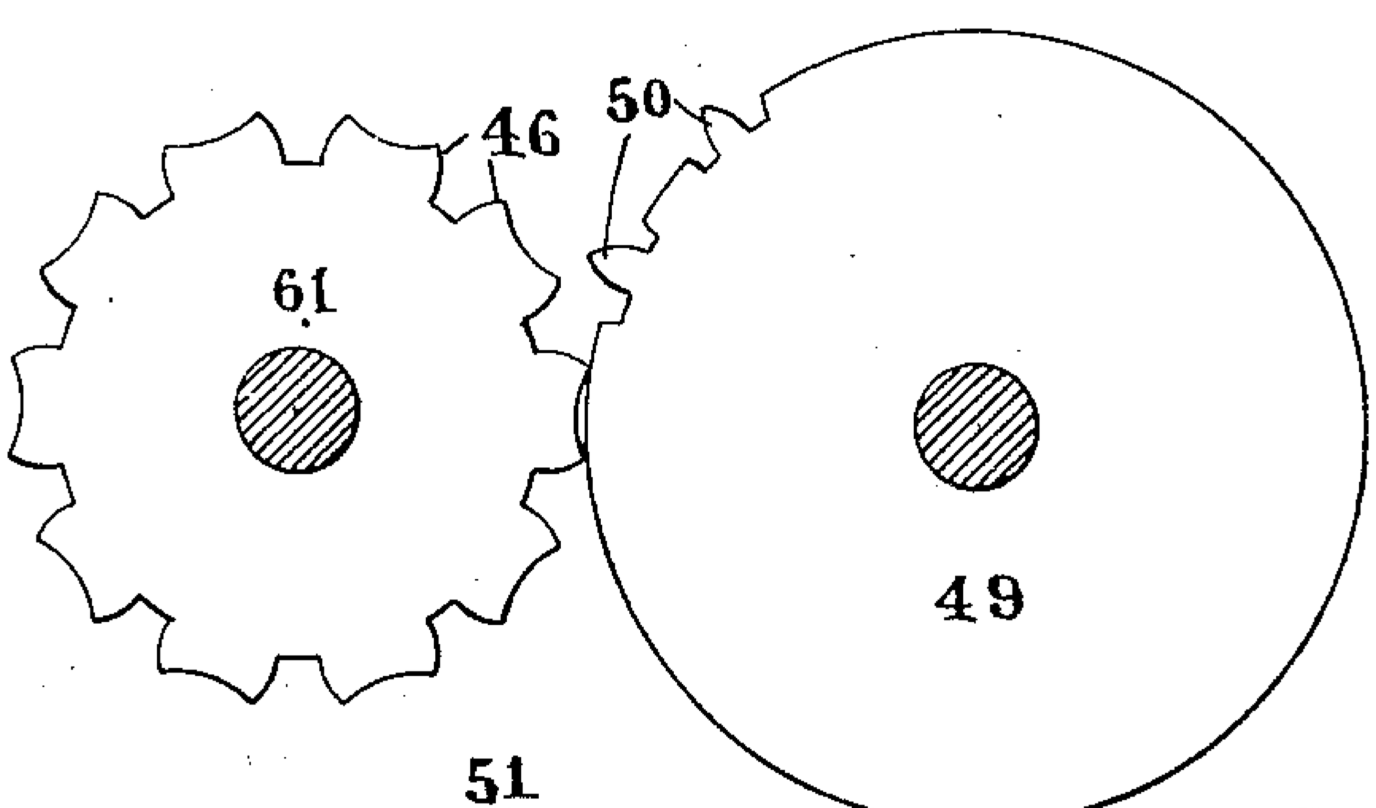


Fig. 7.

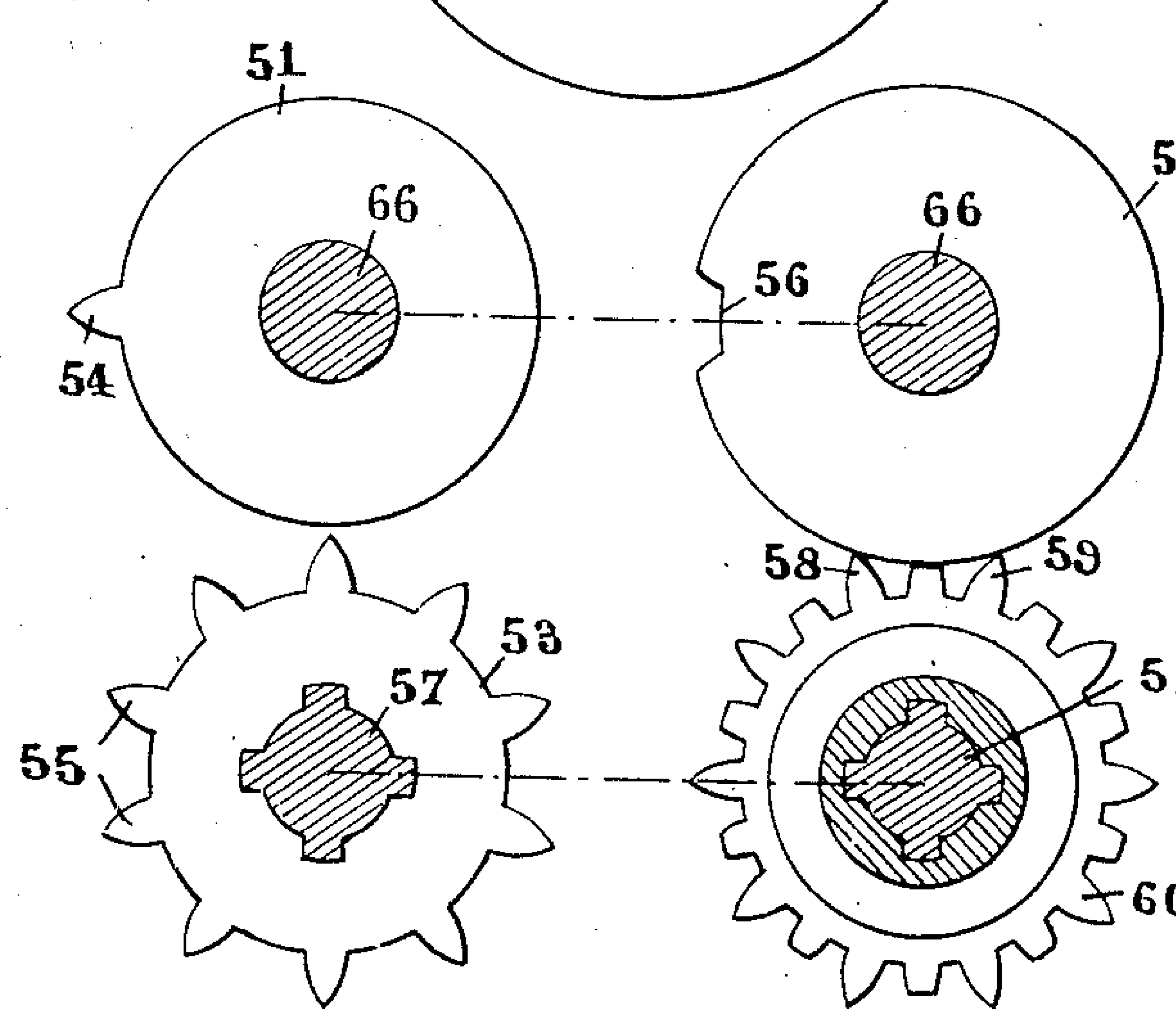
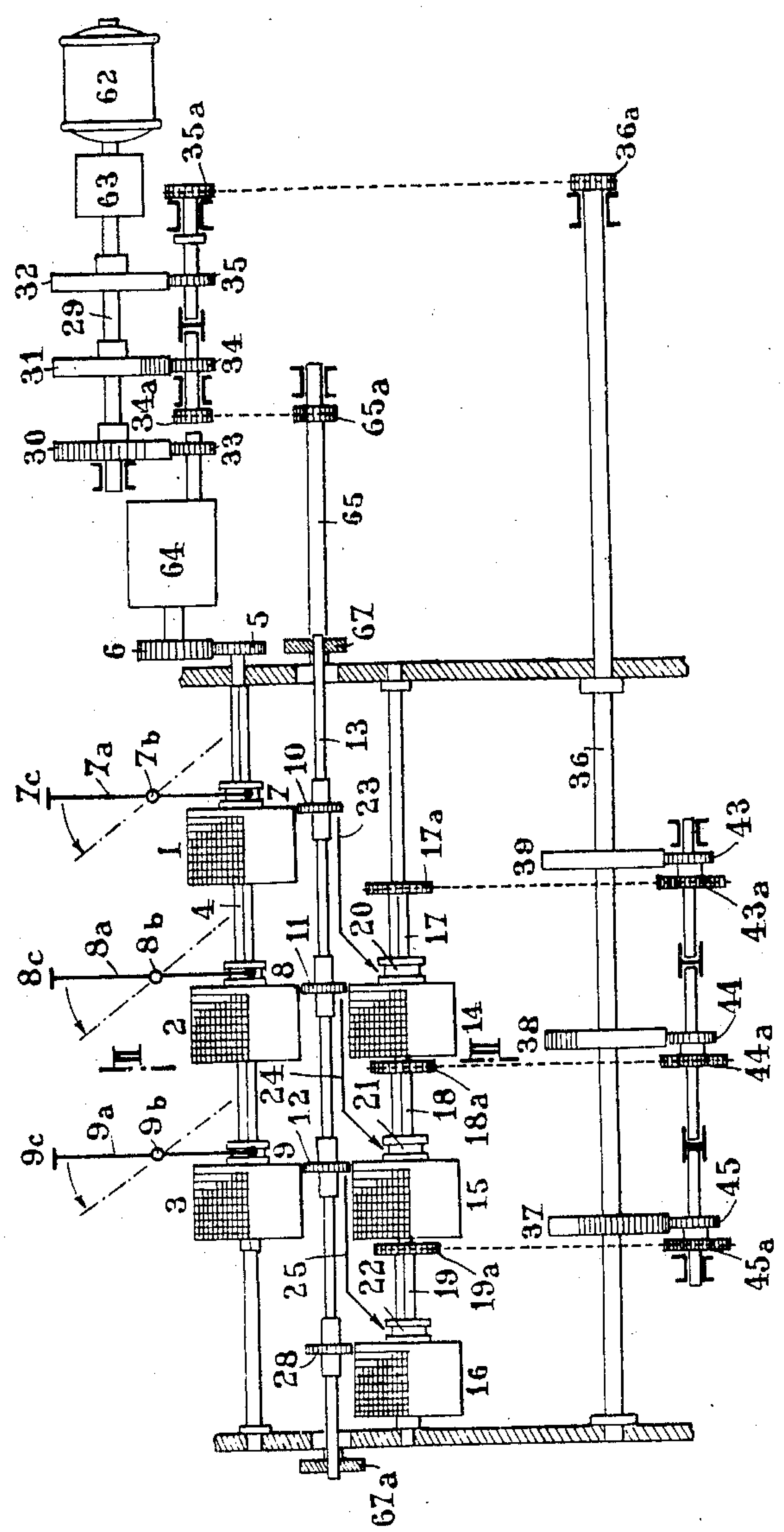


Fig. 8.

Fig. 9.



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TRANSFER SYSTEM FOR CALCULATING MACHINE

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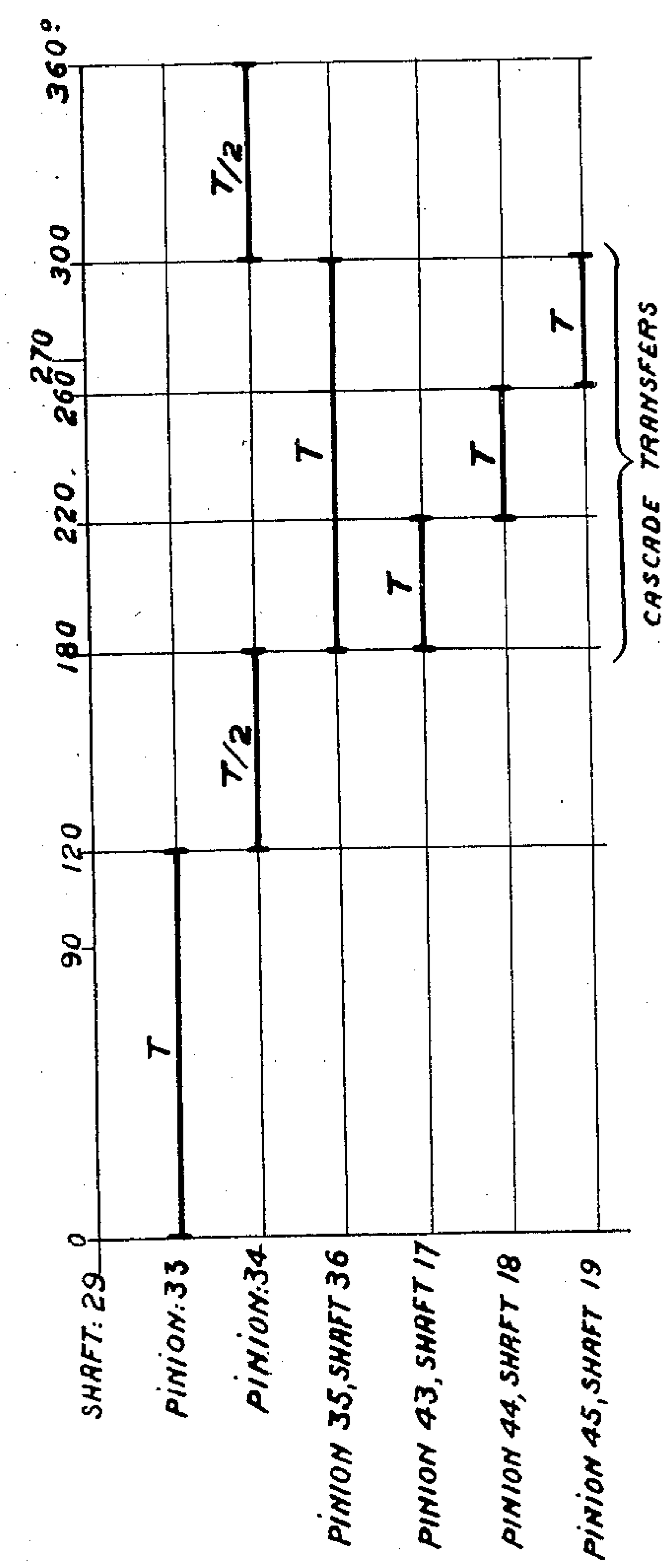
Fig. 10.



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TRANSFER SYSTEM FOR CALCULATING MACHINE

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Claims priority, application France Jan. 13, 1955

1 Claim. (Cl. 235—138)

The present invention relates to an improved transfer system for calculating machine whereby a doubly deferred cascade recording of the transfers combined with the use of a power input may be effected.

For this purpose, the transfer system according to this invention is characterized in that it comprises for each row of units, except for the first one, a transfer block consisting of an adequate number, for example ten, of pinions rotatably fast with one another, each pinion having a toothed segment of which the number of teeth increases regularly from the first pinion to the last pinion in the block, i.e. from zero to nine in the decimal system, and a complementary smooth or toothless segment of which the diameter corresponds to the pitch circle of the teeth, an input pinion having 10 teeth in the decimal system which constitutes the input pinion of a totalizer, this last-mentioned pinion being adapted to co-act with the different pinions of said block, means adapted upon each transfer actuation of a given order to bring about a relative displacement between the transfer block of the immediately succeeding upper order and the associated input pinion, whereby said associated input pinion will be caused to register with that pinion from the transfer block which has one tooth more than the pinion with which it was registering beforehand, and means adapted, subsequent to each partial multiplication, to rotate through a complete revolution successively each of the said transfer blocks by beginning with the pinion block of the lowest order so as to transmit in cascade the transfer to the associated input pinions of a totalizer.

A power input may be used for bringing about the cascade rotation of the multiplying blocks in the transfer system so that the force required for its operation will be derived from this power input alone.

It is pointed out that in the foregoing and in the following description a pinion having n teeth is a pinion pertaining to a multiplying block which comprises a toothed segment and a smooth or toothless segment having the same diameter as the pitch circle of the toothed portion; in other words, not a pinion having actually n teeth, but a pinion of which a complete revolution causes the conjugate pinion to rotate through an angular extent corresponding to n units.

Similarly, in the foregoing and in the following description a p-toothed input pinion of a multiplying block is a pinion of which the total number of teeth corresponds to p units, adapted to be locked against rotation by any smooth or toothless segment of anyone conjugate pinion of the multiplying block and driven through the angular extent corresponding to the number of teeth carried by the conjugate pinion.

In order to afford a clearer understanding of the invention and of the manner in which the same is to be carried out in the practice, reference will now be made to the attached drawings forming part of this specification and illustrating diagrammatically by way of example

one form of embodiment of the invention as applied to a rotary multiplying-divider of the type described in the U.S. Patent No. 2,838,236 of June 10, 1958.

In the drawings:

Figure 1 is a diagrammatical view of the assembly;

Figure 2 is a fragmentary diagrammatic view of the assembly taken upon the line II—II of Fig. 1;

Figures 3 to 5 illustrate schematically an arrangement for controlling the actuation of the transfer pinion block, a device for synchronously controlling the different succeeding operations, and a device for the cascade control of transfers, respectively;

Figures 6 to 8 show another form of embodiment of conjugate pinions;

Figure 9 is a complete diagrammatic view of the assembly; and

Figure 10 is a timing diagram corresponding to an operation cycle.

The machine illustrated in the drawings comprises a number of multiplying groups or block of pinions **1**, **2**, **3** mounted for axial sliding movement on a splined shaft **4** rotatably driven from a pair of pinions **5**, **6** of which the latter is adapted to cause the former to rotate through a number of revolutions ranging from zero to nine, according as the multiplication is effected by a number comprised between 0 and 9.

Each pinion group **1**, **2** and **3** corresponding respectively to succeeding orders comprises ten pinions each having a toothed segment the number of teeth of which increases regularly from 0 to 9, according to an arithmetical progression of ratio n from the first to the last pinion of the group, and a complementary toothless segment of a diameter corresponding to the pitch circle of the aforesaid teeth; grooved collars **7**, **8**, **9**, rigid with the groups of pinions **1**, **2**, **3** are driven from one end of the levers **7a**, **8a**, **9a** pivoted on pins **7b**, **8b**, **9b**, the other end **7c**, **8c**, **9c** of each lever being adapted to be set by the operator in the position corresponding to the multiplicand figure. As a result, a sliding movement of the pulleys **7**, **8**, **9** and groups of pinions **1**, **2**, **3** so that the pinion having the desired number of teeth will mesh with the corresponding input pinions **10**, **11**, **12** mounted for loose rotation on a common shaft **13**. These pinions **10**, **11**, **12** have 10 n teeth in the decimal system and every n tooth is truncated down to the pitch circle; in other words, if we consider the succession of these teeth on one of the pinions we see $n-1$ complete teeth, one truncated tooth, $n-1$ complete teeth, one truncated tooth, and so forth. In the example illustrated in the drawings the blocks **1**, **2**, **3**, **14**, **15**, **16** consist of ten-pinion assemblies wherein the number of teeth is respectively 0, 3, 9, 12, . . . 27, the rate n of the arithmetical progression being equal to 3. Therefore, in the same example the teeth **10**, **11**, **12** have $10\times3=30$ teeth of which every third one is truncated; otherwise stated, if we consider the succession of teeth of these pinions, we find two complete teeth, one truncated tooth, two complete teeth, one truncated tooth, and so forth. Thus, the pinion **10**, for instance, may be driven by one pinion of the multiplying group **1** and subsequently locked by virtue of the engagement of one truncated tooth with the complementary toothless segment of the said multiplying pinion.

Ten-pinion transfer blocks **14**, **15**, **16** similar to the multiplying groups **1**, **2**, **3** are also slidably mounted on separate sections **17**, **18**, **19** of splined shafts; each block is rotatably and slidably fast with a grooved collar **20**, **21**, **22** whereby, through appropriate actuating mechanisms **23**, **24**, **25** illustrated diagrammatically in Fig. 9, upon each rotation through a complete revolution of one of the input pinions **10**, **11**, **12** the ten-pinion transfer blocks **14**, **15**, **16** associated with the input pinion of the immediately succeeding upper order will slide through an axial distance corresponding to the width of one of these pinions, so that the input pinion will register with that pinion from said block which has one tooth more than that with which it registered beforehand.

This displacement may be obtained by means of a tappet **40** rigid with each input pinion **10, 11, 12** and cooperating with other tappets **41** rigid with a sliding rod **42** so that, upon completion of each revolution of the relevant input pinion, an angular displacement of at least one tooth of said pinion will cause the tappet assembly **40, 41** to displace the sliding rod **42**. To this end, the rod **42** carries a rack **70** meshing with a spur gear **71** rigid with the bevel pinion **72**. The bevel pinion **73** meshing with pinion **72** is rigid with a spur pinion **74** meshing in turn with the rack **75** solid with a rod **76** having a fork-shaped end associated with the collar **20**. The gear ratio of rod **42** to rod **76** is so selected that an elementary movement of rod **42** under the control of a tappet **40** determines a longitudinal shift of the ten-pinion transfer block **14** which is equal to the width of one of the pinions constituting this block.

Each of the pinions **10, 11, 12** may be in constant meshing engagement with the pinion **26** of the corresponding row of a totalizer and mounted for rocking movement from one extreme position to another, the rocking movement being such that in one of their extreme positions they will mesh with the pinions of one of the ten-pinion groups **1, 2, 3** and in the other extreme position they will mesh with one of the pinions of the ten-pinion groups **14, 15, 16**; this rocking movement may be produced by an eccentric **27** mounted on a shaft **65** adapted when rotated through 180 degrees to tilt the stirrup consisting of the arms **67, 67*a*** on which is journalled the shaft **13**, and the input pinions **10, 11, 12** carried by this shaft will thus shift from one of their extreme positions to the other.

The device described hereinabove operates as follows: The input pinions **10, 11, 12** are firstly in meshing engagement with the multiplying groups of pinions **1, 2, 3**; the gearing **6, 5** rotates the splined shaft **4** and the multiplying pinion groups **1, 2, 3** carried thereby through a number of revolutions corresponding to the desired multiplication; meanwhile the groups of deferred transfer pinions **14, 15, 16** are not in meshing engagement with the input pinions **10, 11, 12**; they are in their inoperative positions, the toothless pinion of each of these groups registering with the relevant input pinion; each time one of these input pinions **10, 11, 12** accomplishes a complete revolution corresponding to the recording of ten units and that a one-unit transfer is to be effected, it causes through the devices **23, 24, 25** the corresponding group of transfer pinions **14, 15, 16** to slide through the axial distance of one pinion width; as a result, it is in succession the pinion having one, two, . . . nine teeth which registers with the relevant input pinion; when the multiplication is completed, the splined shaft **17** carrying the pinion group **14** is rotated through one full revolution after having rocked the shaft **13** carrying all the input pinions **10, 11, 12** so as to disconnect them from the multiplicand pinion groups **1, 2, 3** and to cause them to mesh with the transfer pinion groups **14, 15, 16**; thus, the transfer pinion **14** causes the input pinion **11** to rotate through the number of teeth corresponding to the number of transfers previously recorded thereby; then the transfer pinion **15**, followed by the transfer pinion **16**, etc. . . . up to the last transfer pinion, are rotated through a full revolution.

Consequently, the transfers are thus recorded in cascade and transmitted through the toothed pinions **26** to the totalizer.

Assuming for example a multiplicand 875 to be multiplied by the multiplier 9; the groups of pinions **1, 2, 3** are caused to slide until the five-toothed, seven-toothed and eight-toothed pinions of these groups respectively are in meshing engagement with the input pinions **10, 11, 12**; then the splined shaft is given nine turns. As a result, the receiving input pinion **10** makes a forty-five teeth turn, and input pinion **11** makes a sixty-three teeth turn and the input pinion **12** makes a seventy-two teeth turn; the totalizer input pinions will therefore indicate five units, three units, and two units, respectively, and the transfer pinion groups **14, 15** and **16** are axially shifted so as to position the four, six and seven toothed wheel of the respective groups **14, 15** and **16** in alignment with the gears **11, 12** and **28** respectively; after rocking the shaft **13** a complete revolution is imparted to each group of pinions **14, 15, 16**; as a result, the pinion group **14** will add four units to the three previously recorded by the pinion **11**, and the latter will display 4+3=7 units; the pinion group **15** will add six units to the input pinion **12** and as the latter as already recorded two units, it will display a total of 6+2=8 units; finally, the pinion group **16** will cause the hitherto inoperative input pinion **28** to record seven units; consequently, the total will be 7,875, which is the product of 875 by 9.

As another example of mutiplication, let it be assumed that the multiplicand 989 is to be multiplied by the multiplier 9. The groups of pinions 1, 2, 3 are made to line up in such a way that the nine-tooth, eight-tooth and nine-tooth pinions respectively, are geared to, or engaged with, the receiving pinions **10, 11** and **12**. After that, the splined shaft **4** is given nine turns. As a result, the receiving-pinion **10** makes eighty-one tooth turn, the receiving-pinion **11** makes a seventy-two tooth turn, and the receiving-pinion **12** makes an eighty-one tooth turn. The input pinions **10, 11** and **12** of the totalizator therefore register respectively one unit, or whole, two units, and one unit, and the transfer pinions **14, 15, 16** have been unkeyed axially in such a way as to bring the eight-tooth, seven-tooth, eight-tooth pinions in place directly opposite to the receiving pinions **11, 12, 28**. When shaft **13** has been rotated, each of the groups of pinions **14, 15, 16** in turn is made to effect a complete revolution. In the first place, the group of pinions **14** adds eight units to the two units registered previously by the receiving pinion **11** so that the latter indicates 8 plus 2 equals 0 unit plus a transfer unit. The result is that the group of transfer pinions **15** is axially unkeyed from a supplementary position and that the eight-tooth pinion of this group appears opposite to the receiving-pinion **12**. After that, when the group of pinions **15** has made a complete turn, it adds eight units to the unit registered previously by the receiving-pinion **12** so that the latter indicates 8 plus 1 equals 9 units. Finally, the rotation of the group of pinions **16** brings about the addition of eight units to the receiving-pinion **28** which up to then had not registered. The total obtained is therefore 8,901, which is the product of 989 multiplied by 9.

These succeeding synchronized operations may be controlled from a shaft **29** driven from a motor **62** through a one-revolution clutch **63**. Thus, one revolution of shaft **29** from 0° to 360° defines a cycle of operation. The shaft **29** carries three pinions **30, 31, 32** each having a toothed segment and a toothless segment; these pinions **30, 31, 32** are in constant meshing engagement with pinions **33, 34, 35** having every other tooth truncated down to the pitch circle; the pinions **30, 31, 32** may have a diameter corresponding to sixty teeth and the pinions **33, 34, 35** a diameter corresponding to eighteen teeth; the pinion **30** may have eighteen teeth followed by a toothless segment corresponding to the missing teeth from the 19th to the 60th; pinion **31** may have two diametrally opposite toothed segments each of nine teeth, corresponding to teeth **21** to **29** and **51** to **59**, separated by toothless segment, as shown; finally, pinion **32** may have a toothed segment of eighteen teeth corresponding to teeth

31 to 49, the remaining peripheral portion constituting a smooth segment.

Thus, to each complete revolution of the shaft **29** which corresponds to a cycle of operation of from 0° to 360° the following parts accomplish respectively and successively (see Fig. 10): pinion **33** a complete revolution from 0° to 120° of the cycle T, pinion **34** a half-revolution from 120° to 180° of the cycle T÷2, pinion **35***a* complete revolution from 180° to 360° of the cycle T, a pinion **34** a half-revolution from 300° to 360° of the cycle T. The reference symbols T and T÷2 applied to the pinions and shafts indicate that these members accomplish respectively a complete revolution or a half-revolution during the cycle period considered. Pinion **33** may drive in succession the shaft of the multiplying pinion of the rotary multiplying-dividing apparatus illustrated in block form at **64** so that the pinion **5** and splined shaft **4** will accomplish *n* revolutions for each revolution of the pinion **33**, when the multiplicand is multiplied by *n*. The pinion **34** drives the shaft **65** synchronously through the intermediary of pinions **34***a* and **65***a* fast with pinion **34** and shaft **65**, respectively; this shaft **65** has also mounted on it the eccentric **27** which is adapted to tilt the receiving or driven pinions **10**, **11** and **12** mounted on shaft **13** from one extreme position to the other. The pinion **34** and shaft **65** perform a half-revolution from position 120° to position 180° of the cycle considered, so that pinions **10**, **11** and **12** are caused to mesh with the group of pinions **14**, **15** and **16**, and another half-revolution from position 300° to position 360° of the cycle to bring these pinions **10**, **11** and **12** in meshing engagement with the groups of pinions **1**, **2** and **3** in view of performing another cycle of operation.

Pinion **35** may drive synchronously through the intermediate pinions **35***a* and **36***a*, a shaft **36** having mounted thereon three pinions **37**, **38** and **39** of a diameter corresponding to sixty teeth and each comprising a single toothed segment of eighteen teeth corresponding to the teeth **1** to **18**, and a smooth or toothless segment corresponding to teeth **19** to **60**, the toothed segments being angularly spaced from each other through 120°, as shown. The pinions **37**, **38** and **39** are in meshing engagement with 18-teeth pinions **43**, **44** and **45** of which every other tooth is truncated down to the pitch circle; thus, a complete revolution of the shaft **36** causes the successive rotation through a full revolution of pinions **43**, **44**, **45**, that is (see Fig. 10) pinion **43** from 180° to 220° of the cycle, pinion **44** from 220° to 260° and pinion **45** from 260° to 300°. The fact of truncating every other teeth of pinions **43**, **44**, **45** down to the pitch circle makes it possible to lock these pinions when they have been rotatably driven by the toothed segment of the corresponding driving pinions **37**, **38** and **39**. Another example of this locking action by a truncated tooth co-acting with a toothless segment is illustrated in Fig. 8; in this case it is evident that the pinion **60** is locked in position by the pinion **52** due to the provision of the truncated tooth between the teeth **58** and **59**. These pinions **43**, **44** and **45** cause the successive rotations through a complete revolution of the splined shafts **17**, **18** and **19** on account of the operative connections provided between pinions **43***a* and **17***a* having the same number of teeth, on the one hand, which are rigid with the pinion **43** and splined shaft **17**, respectively, and similarly between the pinions **44***a* and **18***a*, **45***a* and **19***a*, on the other hand. Consequently, the groups of transfer pinions **14**, **15** and **16** will successively accomplish a complete revolution and produce doubly-delayed cascade transfers.

Of course the form of embodiment of the invention which has been described hereinabove with reference to the attached drawings is given only by way of example and should not be construed as limiting the spirit and scope of the invention.

Thus, as already set forth hereinabove, the ten-teeth input pinions **10**, **11**, **12** may be constructed like the pinion **61** shown in Figs. 6 and 7 with its locking teeth **46** adapted to co-act with *n*-toothed pinions such as pinion **47** of a multiplying block shown in Fig. 6, which has only one tooth **48**, and pinion **49** of Fig. 7 which has only two teeth **50**. Pinion **47**, for example, corresponds to the digit 1 of the multiplicand in one of the groups of pinions **1**, **2** and **3**. Similarly, pinion **49** may be the pinion corresponding to the digit 2 of the multiplicand in the same groups of pinions.

Again, it is also possible to dissociate the "driving" and "locking" functions from each other; for this purpose, as illustrated in Fig. 8, the driving shaft **66** is rigid with the driving pinion **51** and locking cylinder **52**, and the driven shaft **57** is rigid with the driving input pinion **53** and locking pinion **60**; pinion **51** has only one tooth **54** and pinion **53** has ten teeth **55** adapted to be rotatably driven from the tooth **54**; cylinder **52** has a single notch **56** and pinion **60** has twenty teeth of which the addenda of two successive teeth bear against the cylinder **52** and the pinion is thus locked by this cylinder.

Each time the tooth **54** of the driving pinion **51** engages tooth **55** of pinion **53**, the rear tooth **58** of pinion **60** bearing against the locking cylinder **52** may engage the notch **56** so as to become unlocked and rotate until the following tooth **59** will restore the locking condition between these parts.

What I claim is:

A transfer system for calculating machine having a totalizer which comprises for each decimal order except for the unit order a transfer block having a number of pinions rotatably fast with one another, ten in the decimal system, each pinion having a toothed segment of which the number of teeth increases regularly from the first pinion according to an arithmetical progression of ratio to the last pinion, i.e. from zero to 9*n*, and a complementary toothless segment of a diameter corresponding to the pitch circle of the teeth, an input pinion having 10*n* teeth in the decimal system and constituting the input pinion of said totalizer, said input pinion comprising successively *n*—1 full teeth followed by one tooth truncated down to the pitch circle, then *n*—1 full teeth, one tooth truncated, etc., said pinion being adapted to co-act with the different pinions of said block, means adapted, upon each actuation of a transfer of a predetermined order, to control the relative displacement between the transfer block of the immediately succeeding upper order and the associated input pinion, whereby said input pinion will be moved into registering relationship with that pinion from said transfer block which has *n* teeth more than that with which it registered beforehand, and means adapted, after all of the relative displacements between transfer blocks and their associated input pinions have been effected, to rotate successively through a complete revolution, each of said transfer blocks, beginning with the one of lowermost order so as to transmit in cascade the transfers, if any, to the conjugate input pinions of a totalizer.

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