

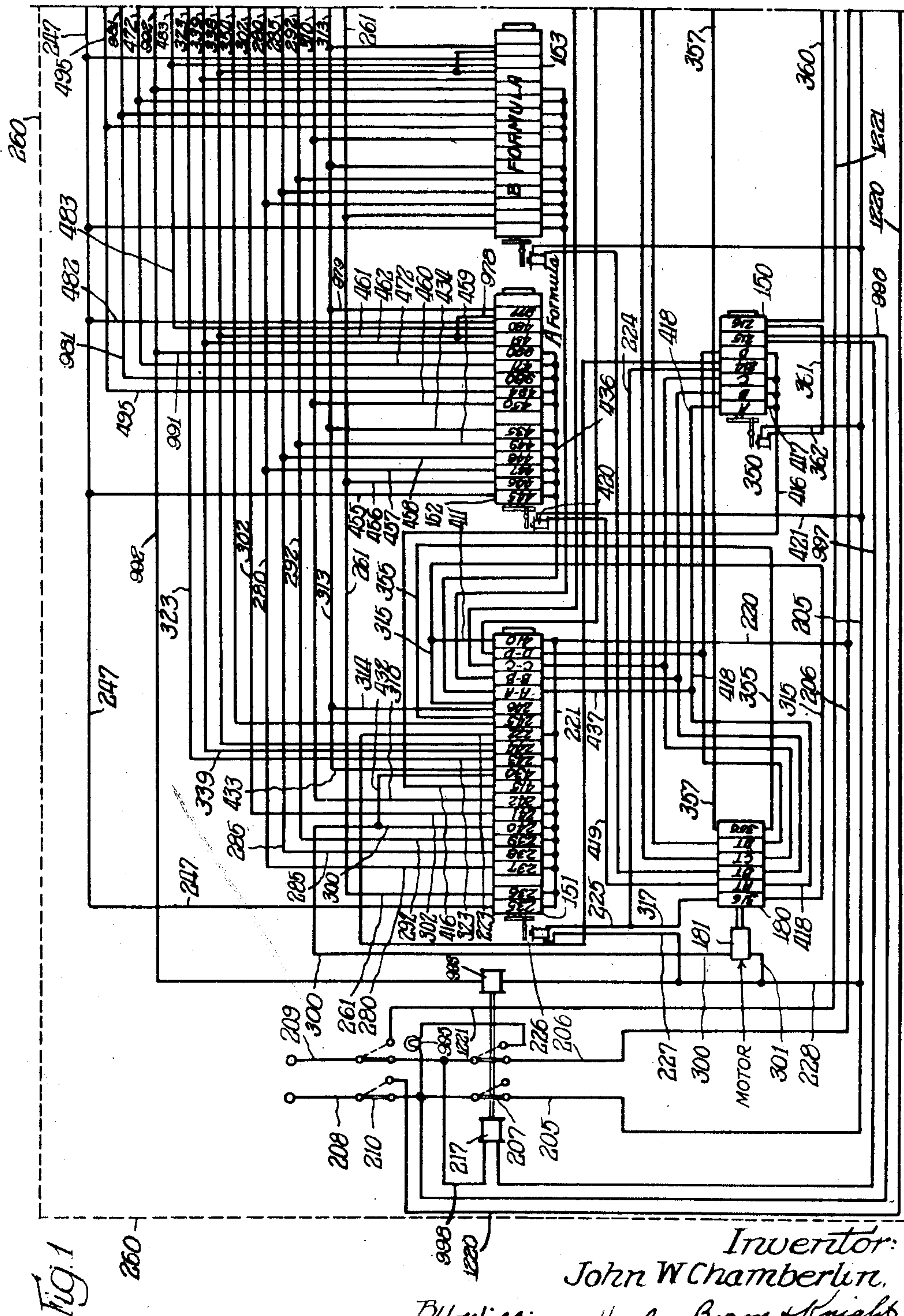
Nov. 11, 1947.

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2,430,668

WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

Original Filed June 16, 1941 18 Sheets-Sheet 1



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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

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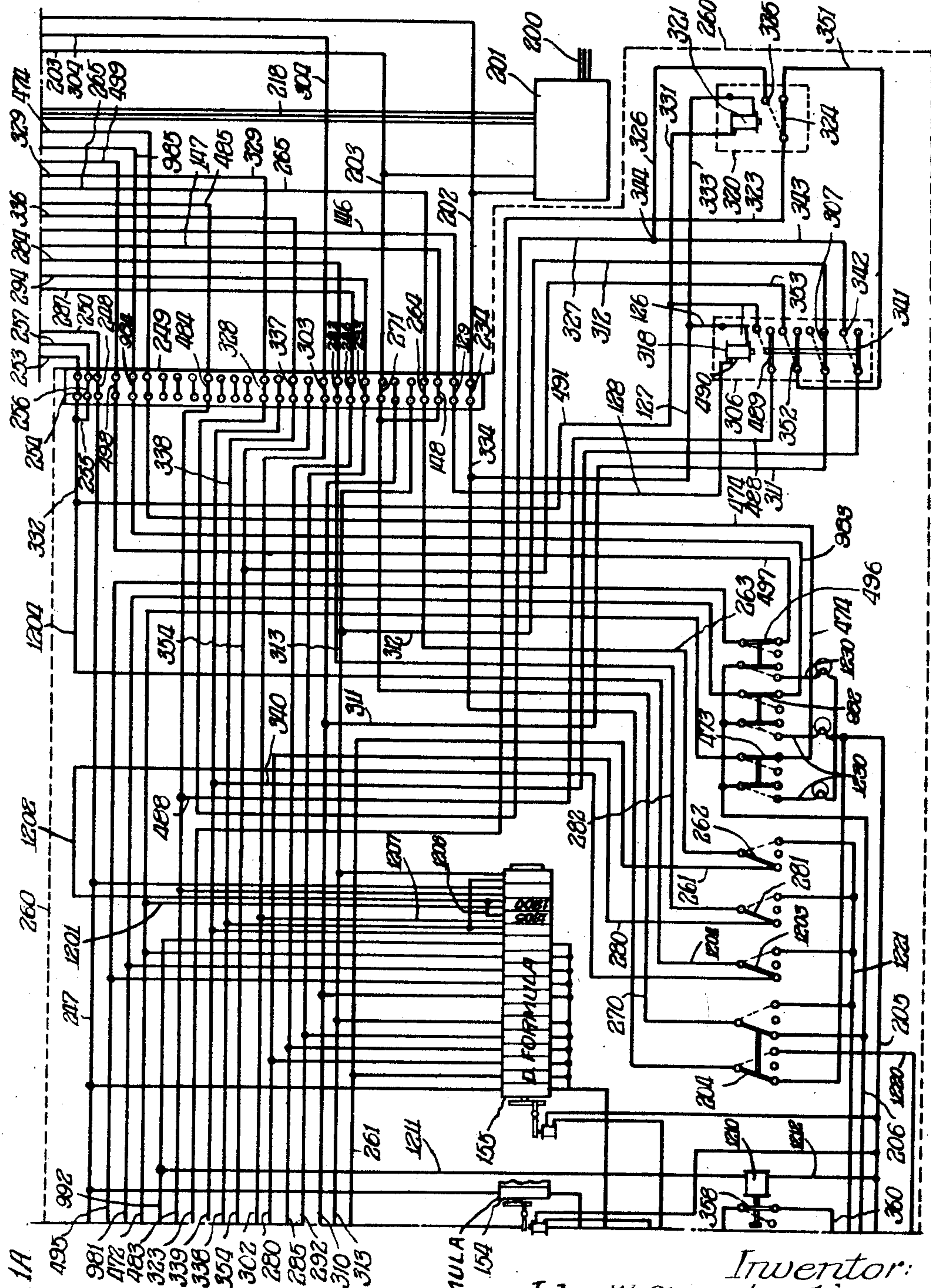


Fig. 1A

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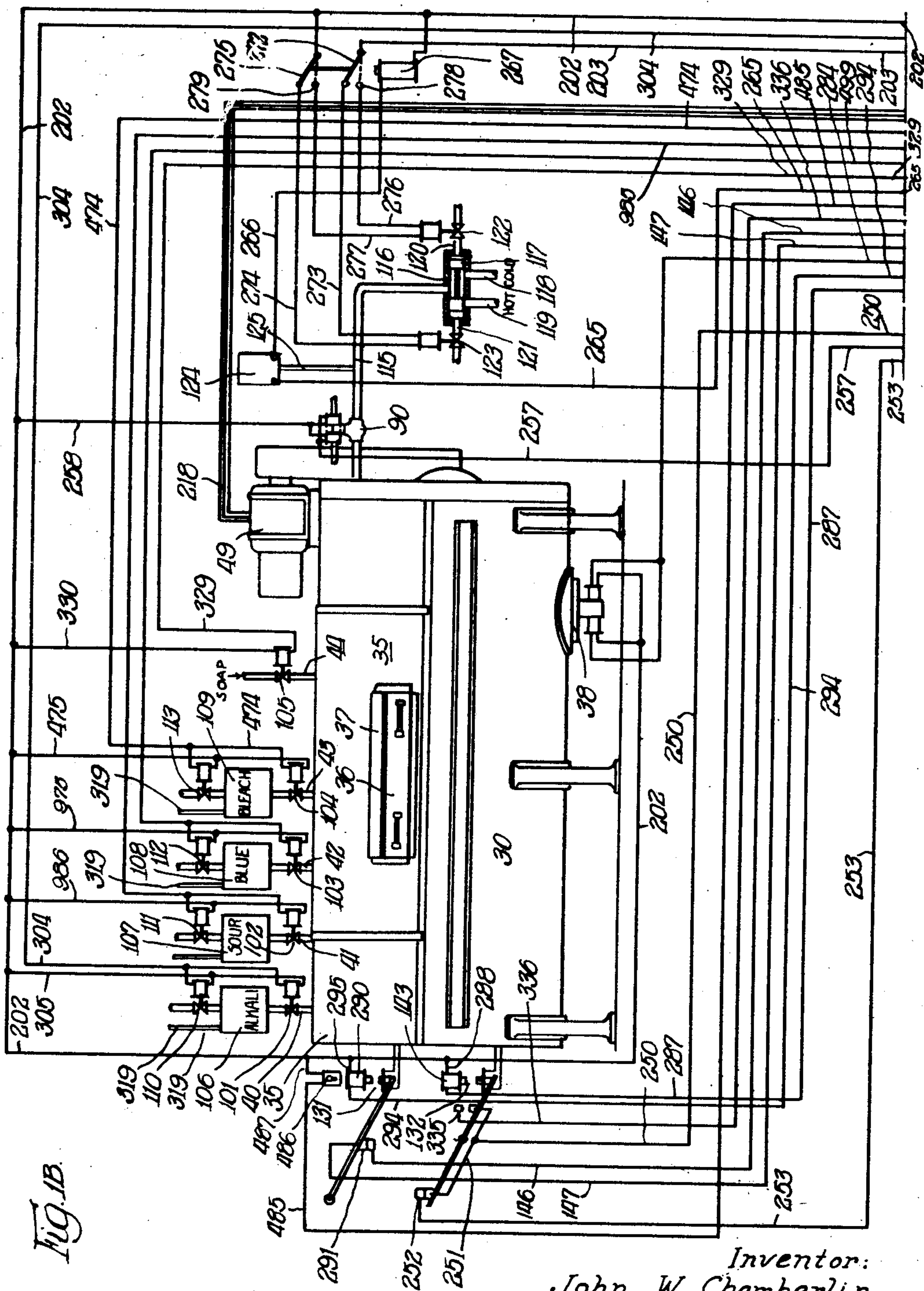
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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

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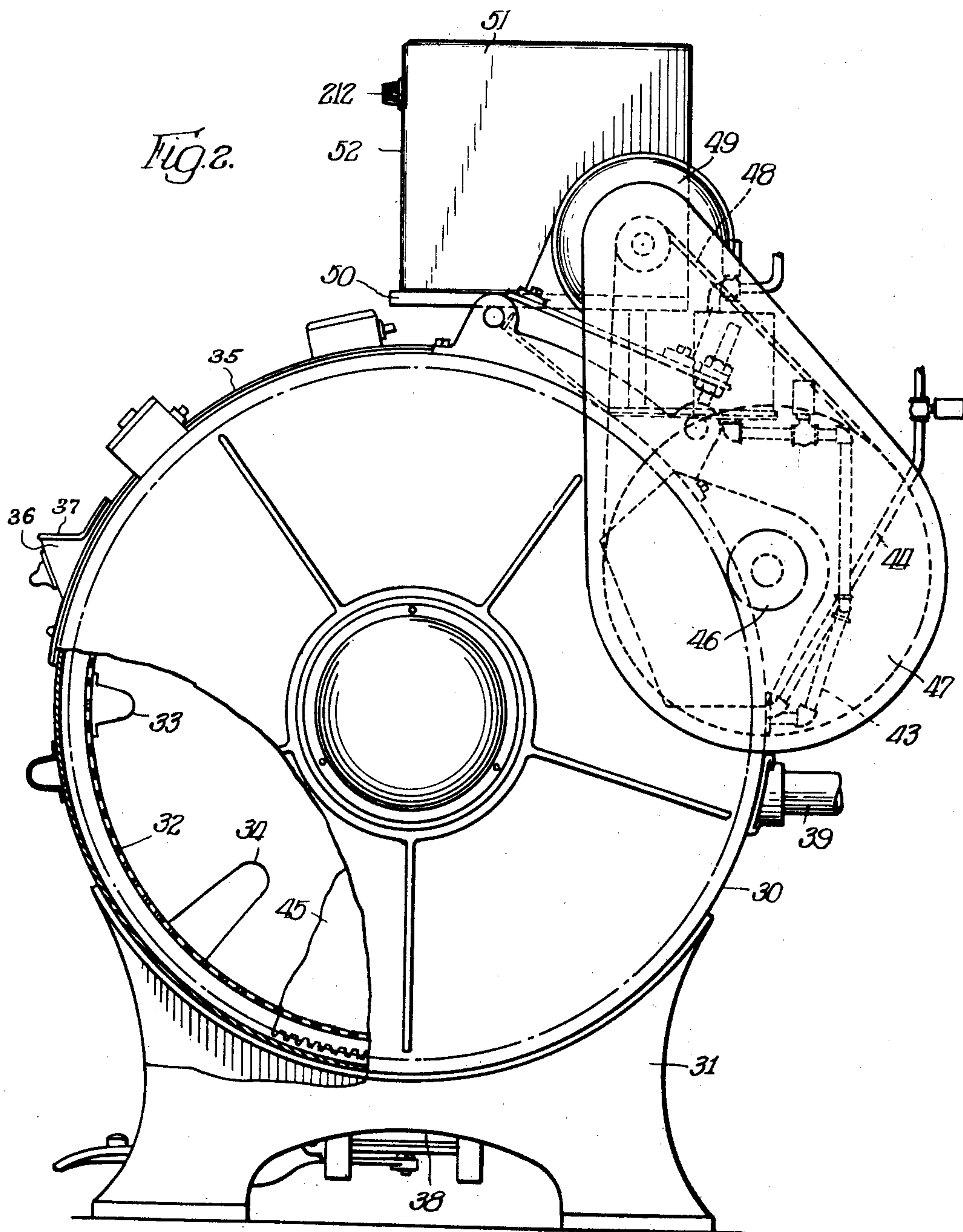
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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

Original Filed June 16, 1941 18 Sheets-Sheet 5

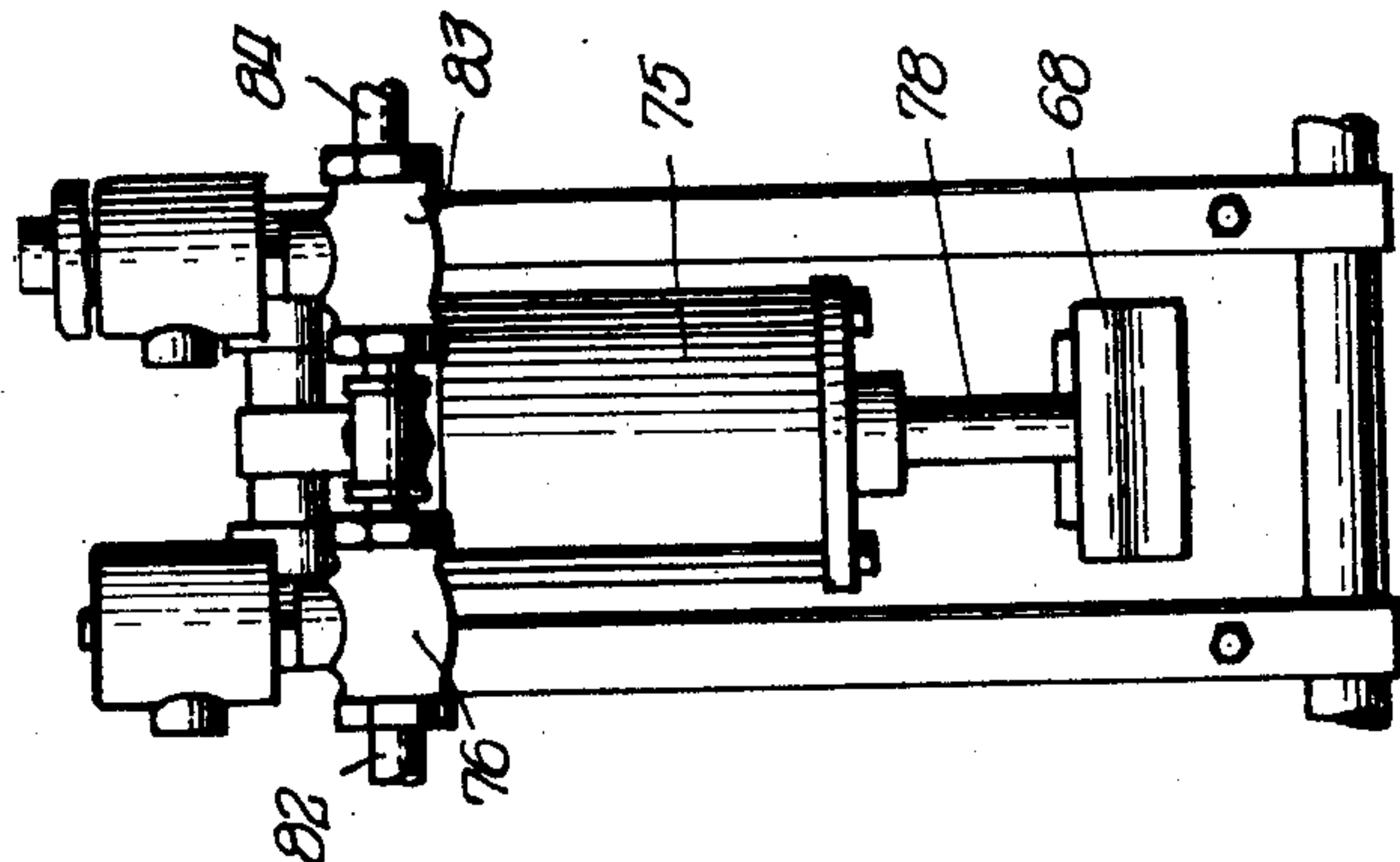


Fig. 4

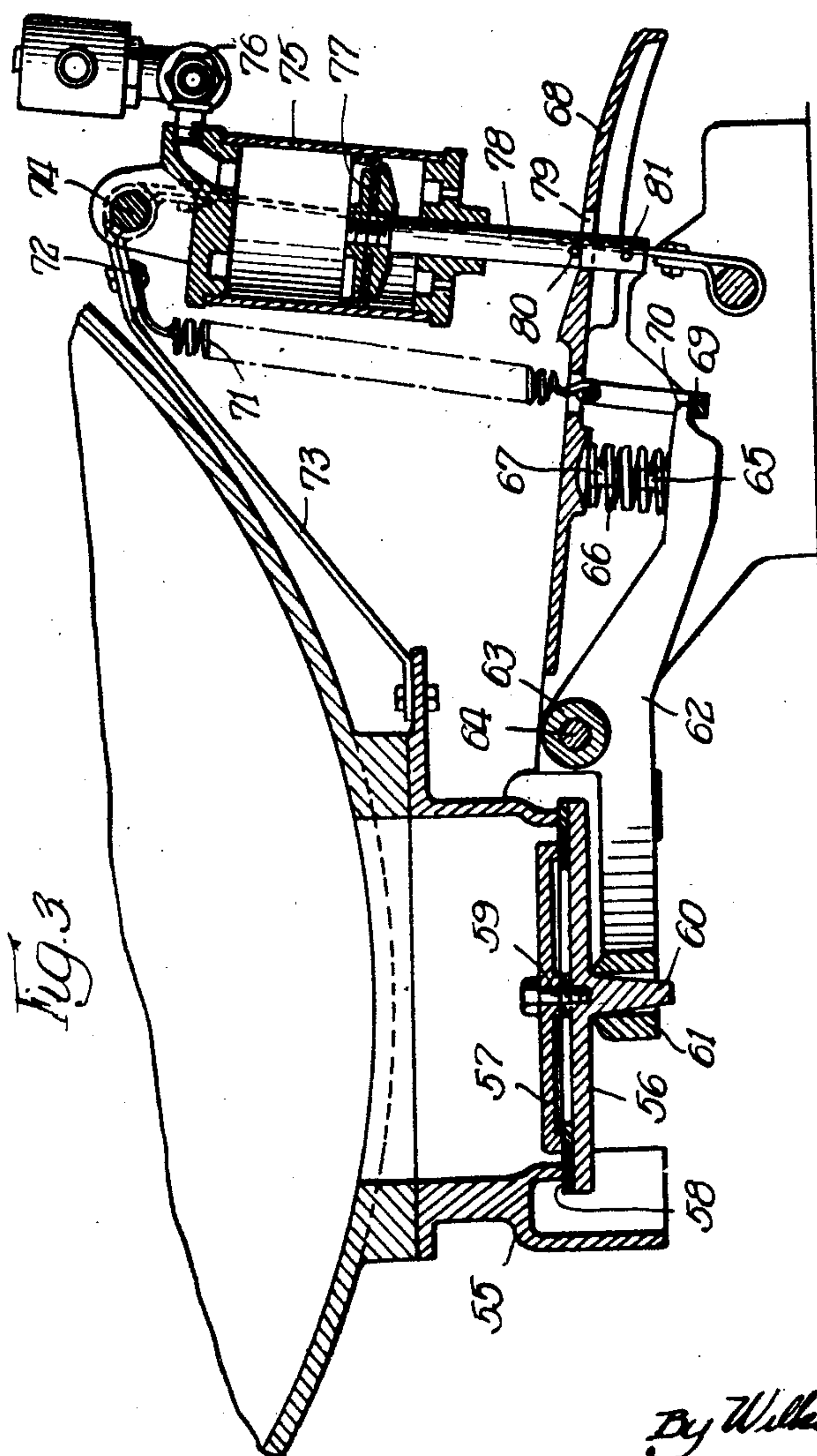


Fig. 3

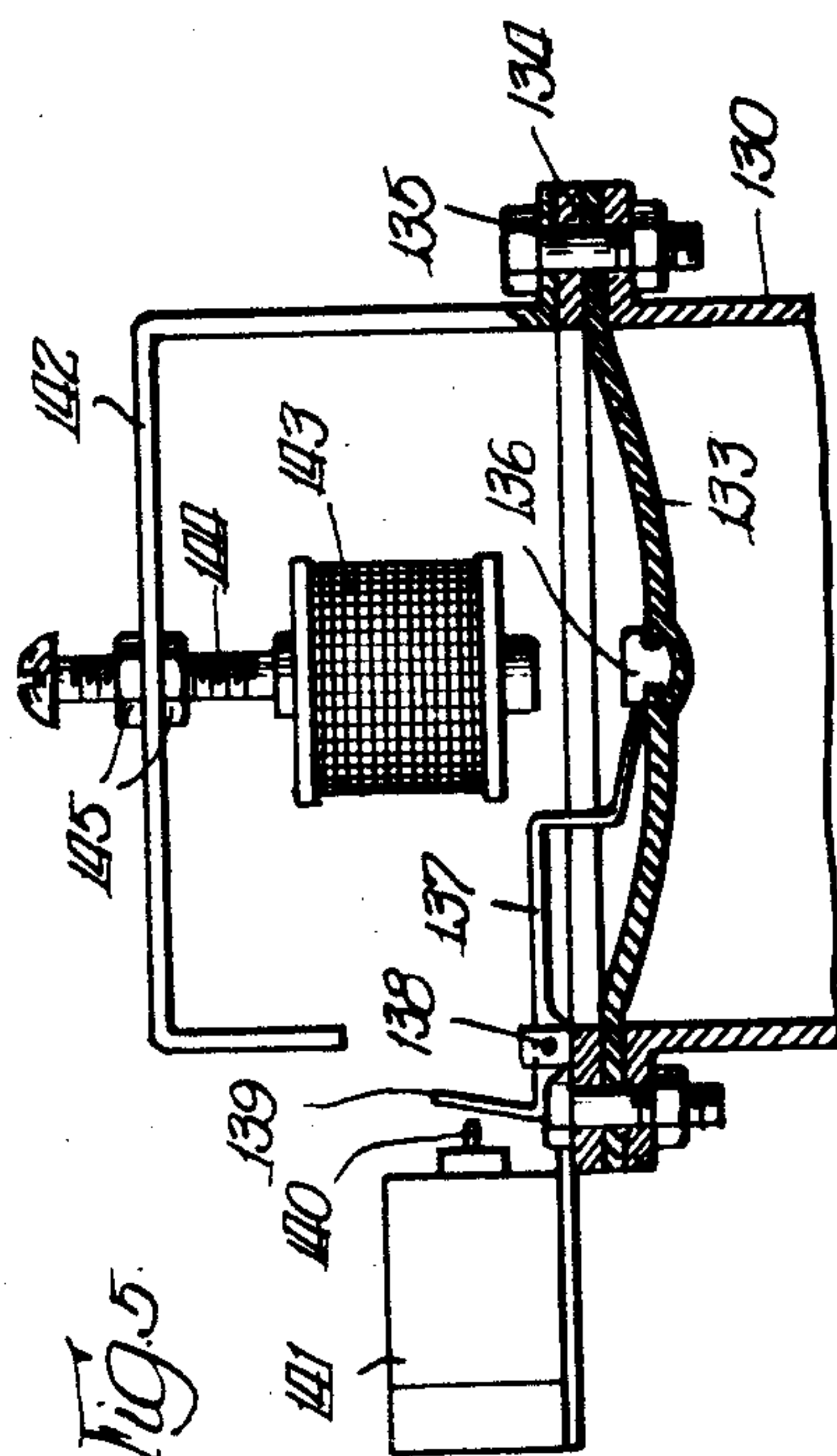


Fig. 5

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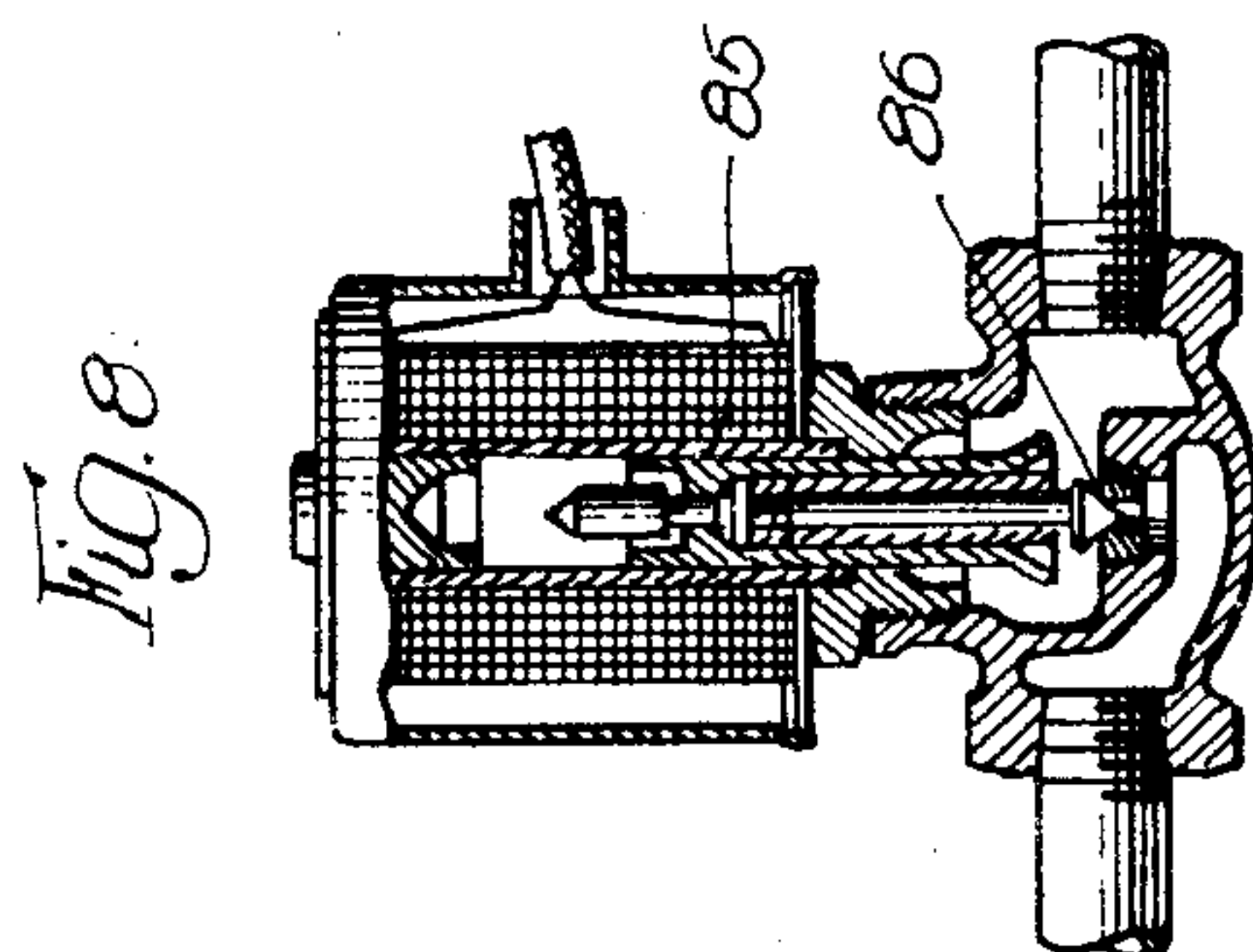
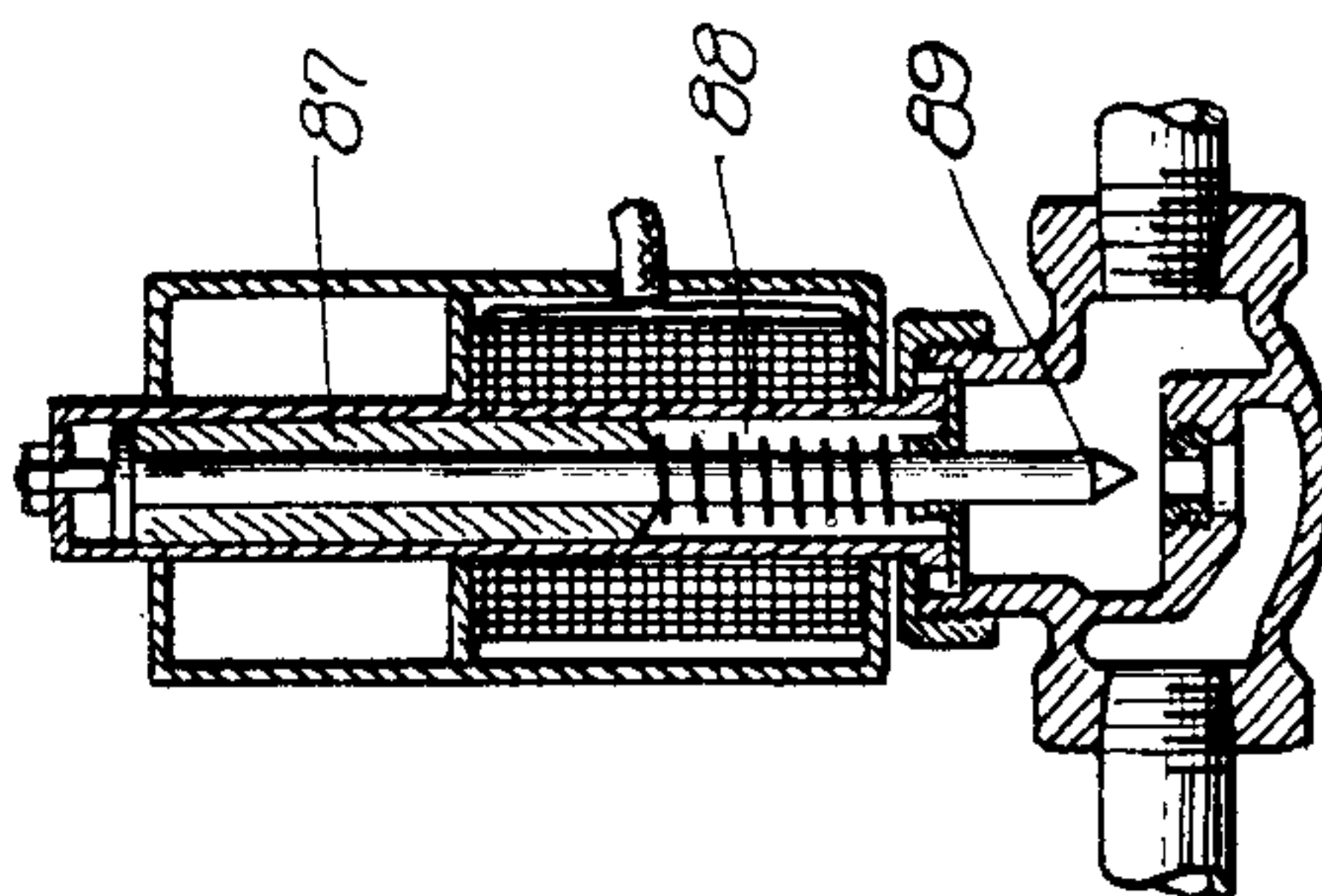
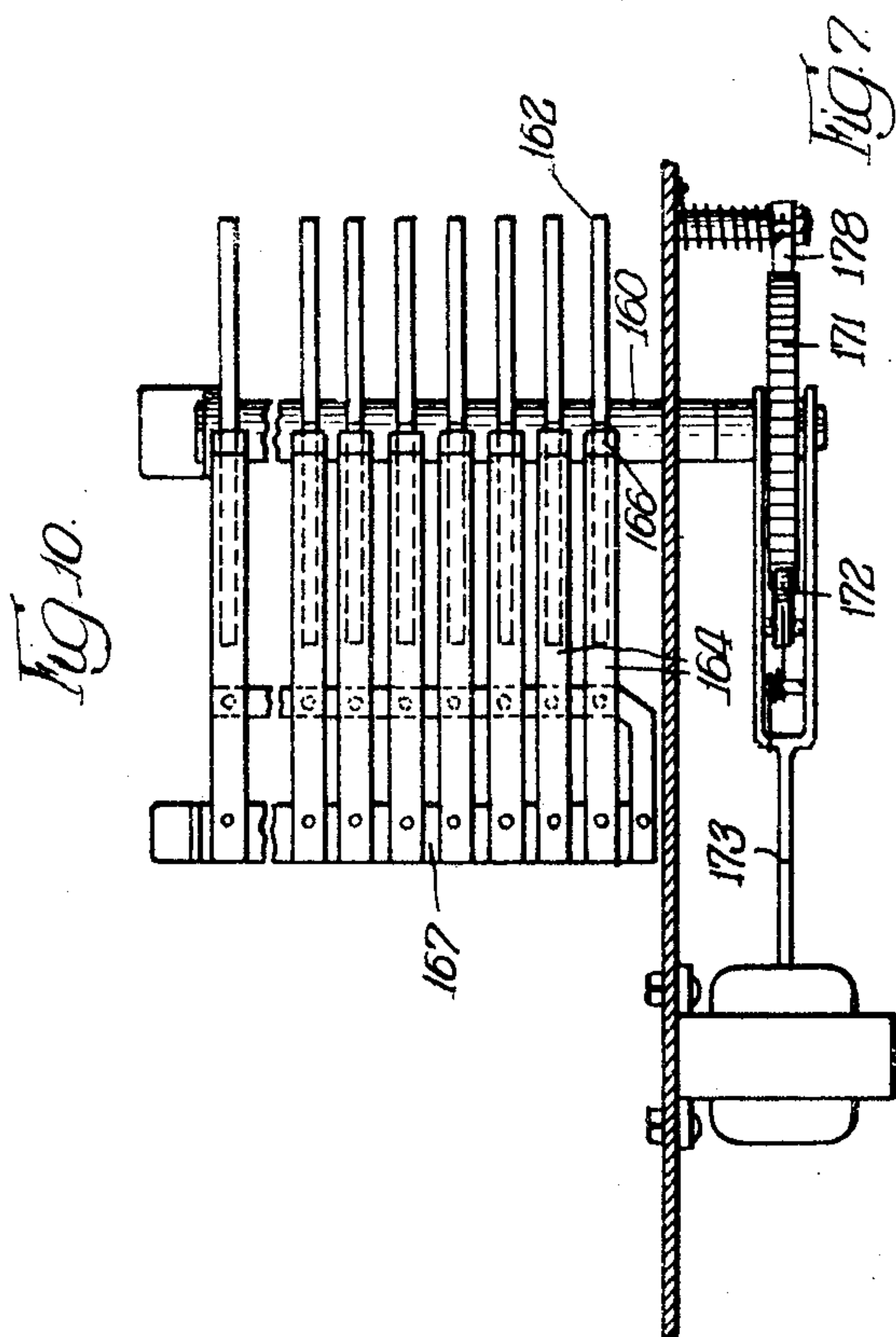
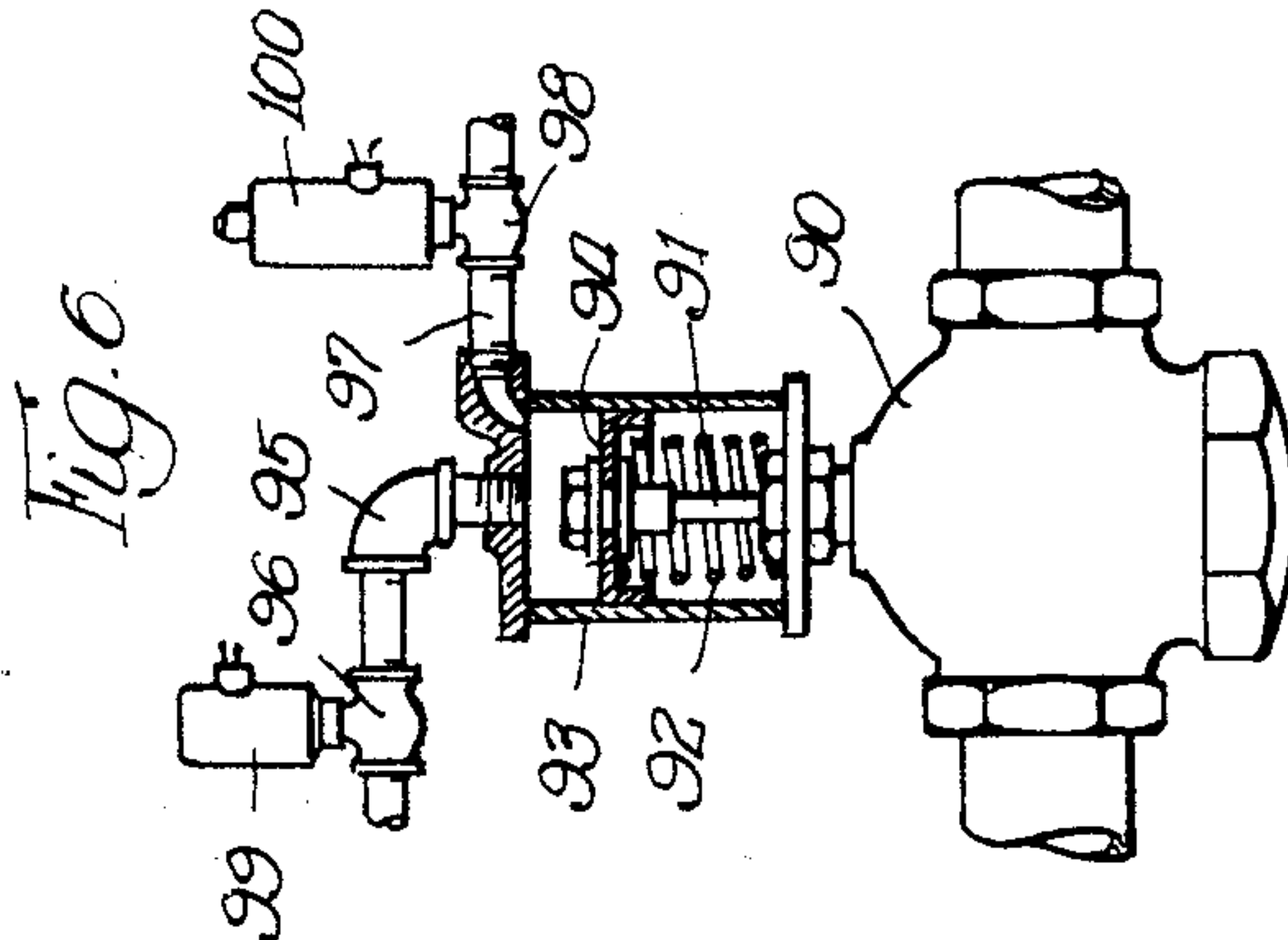
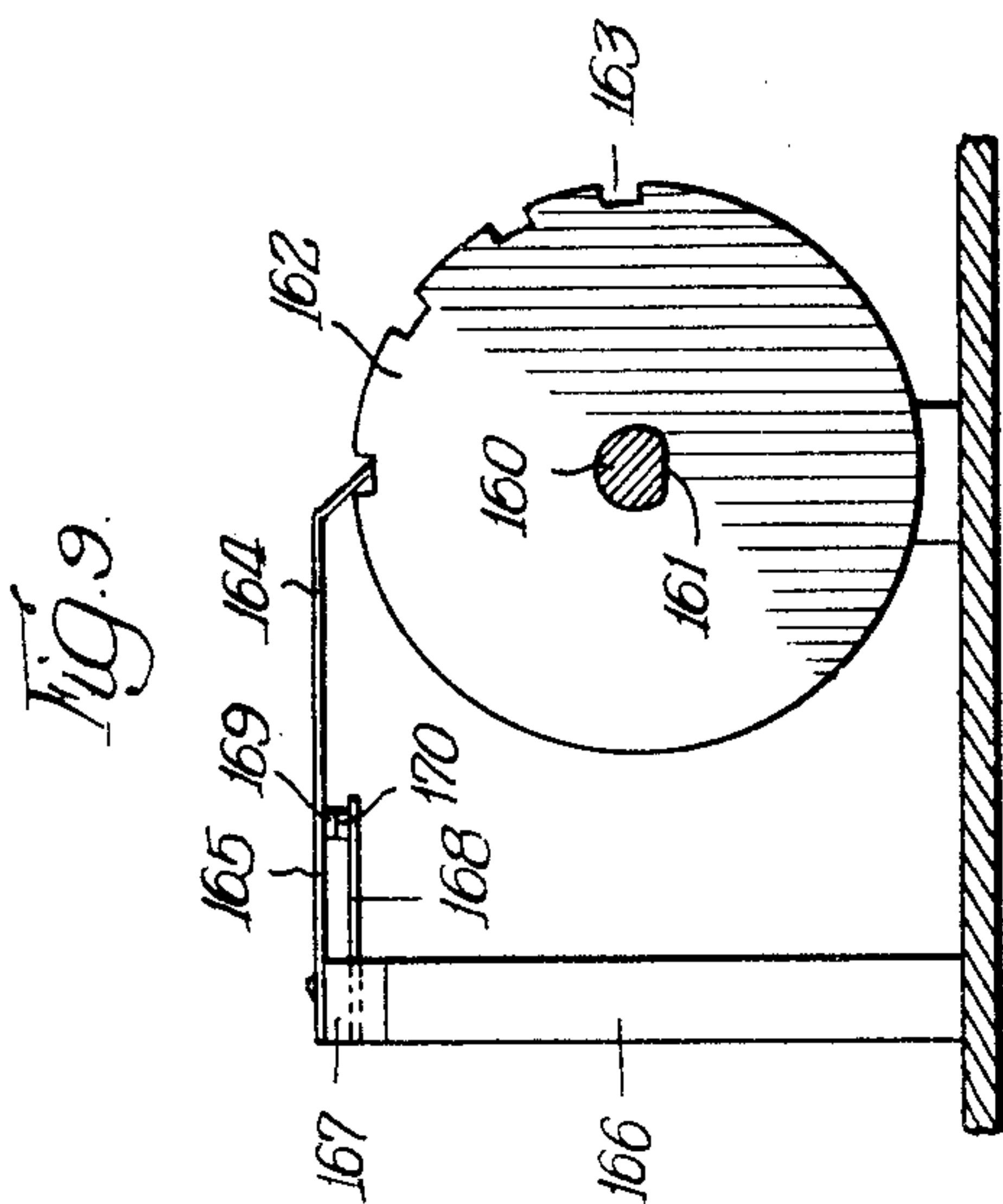
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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

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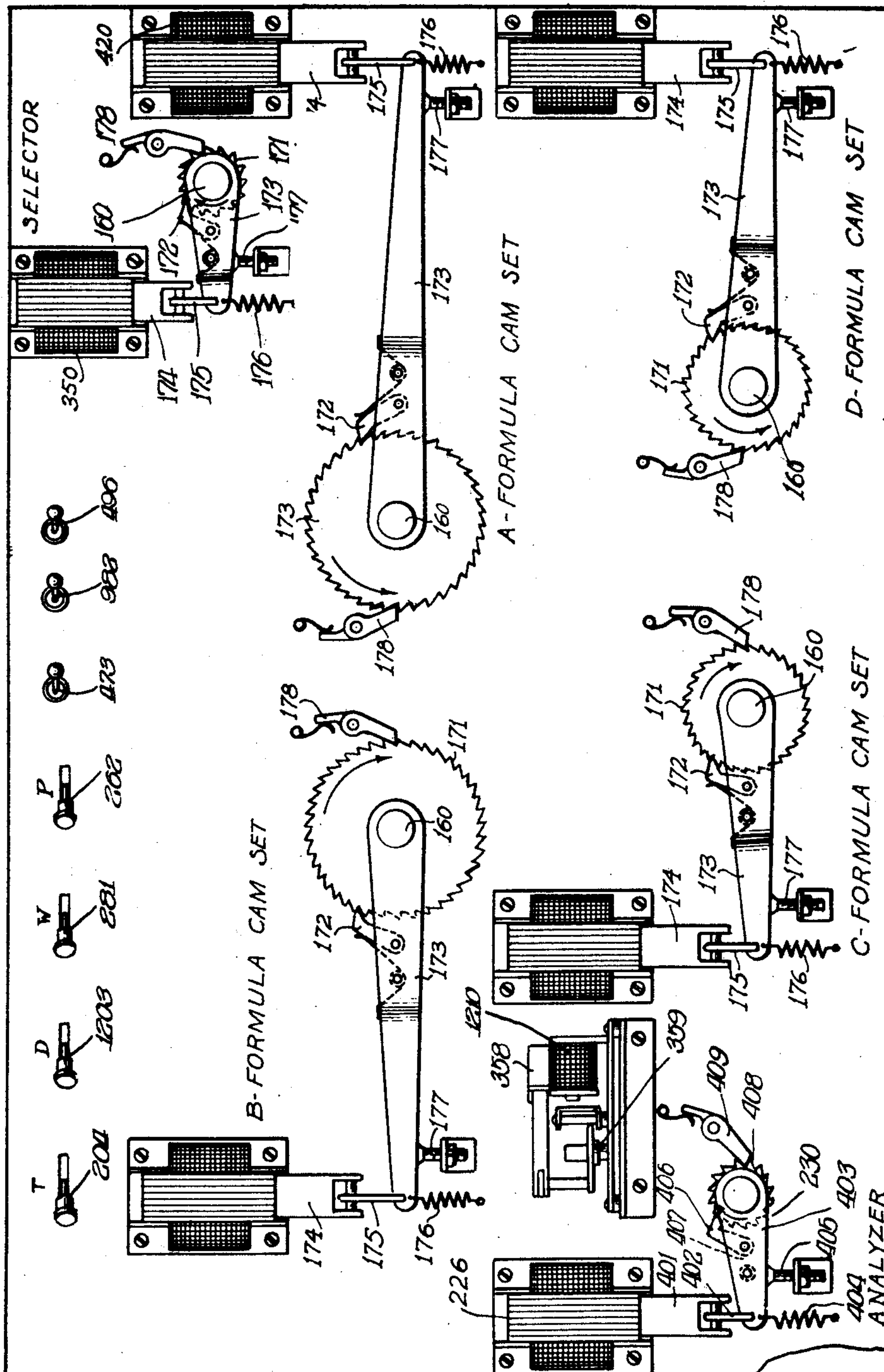


Fig. 11.

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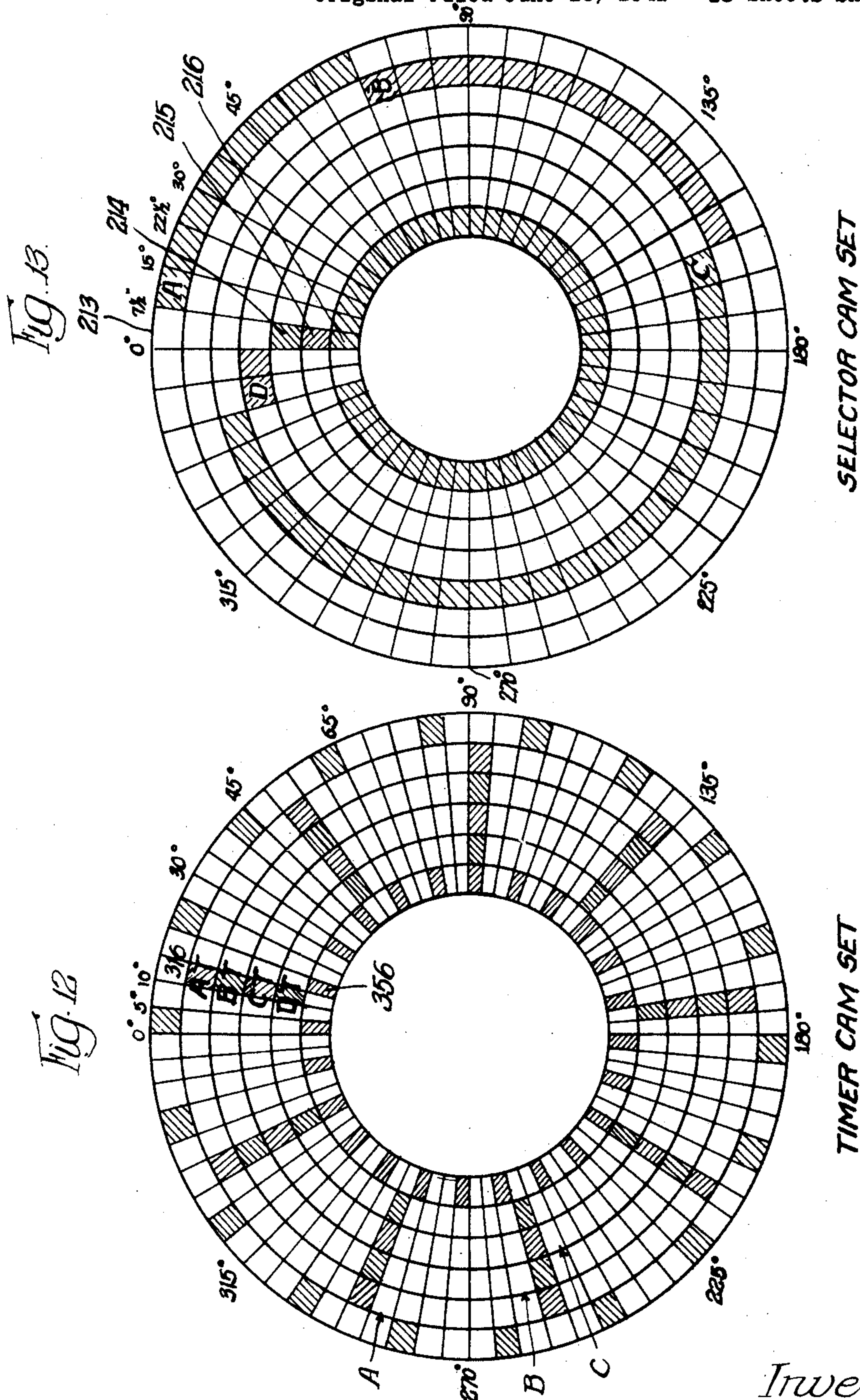
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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

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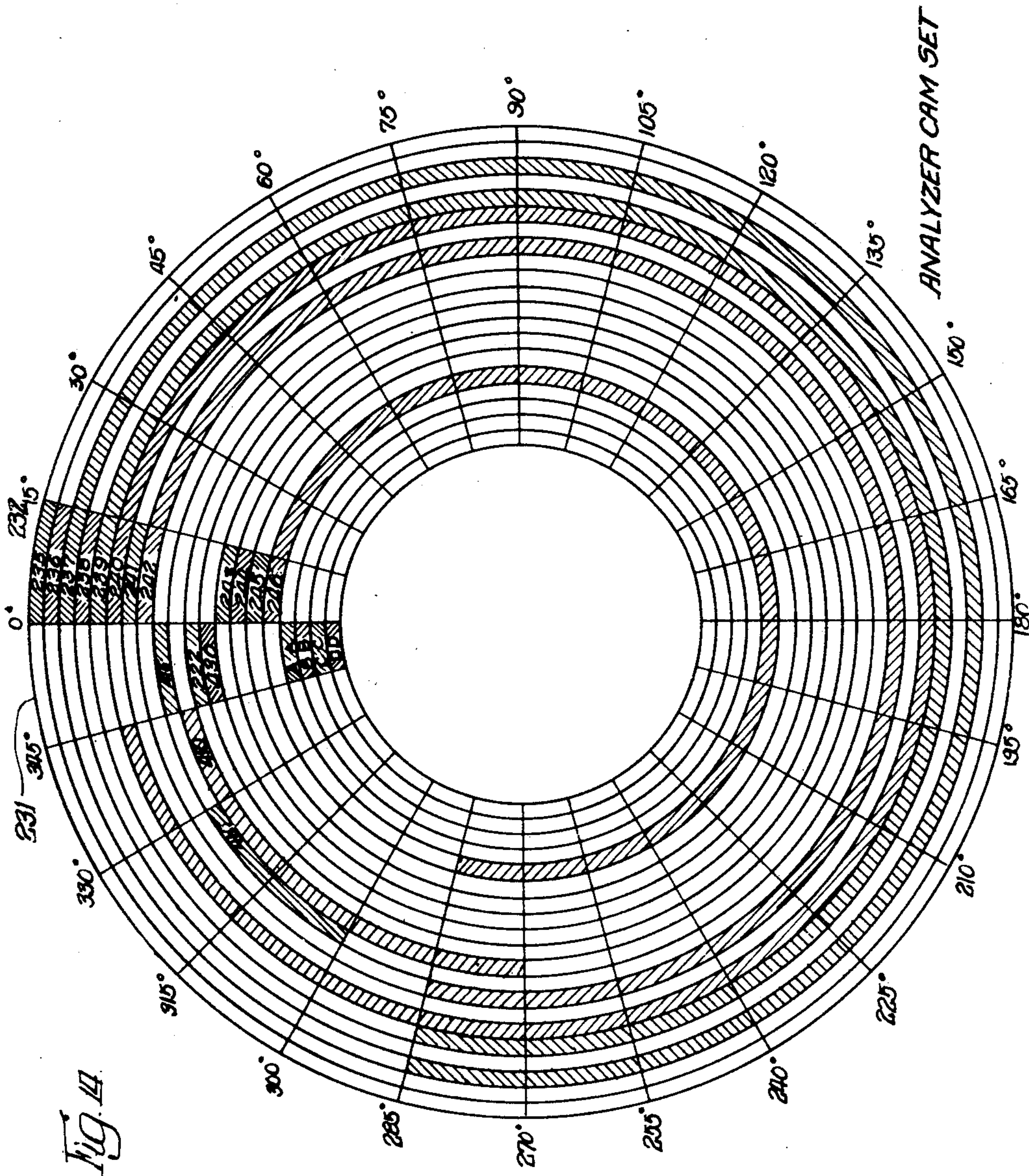
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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

Original Filed June 16, 1941 18 Sheets-Sheet 9



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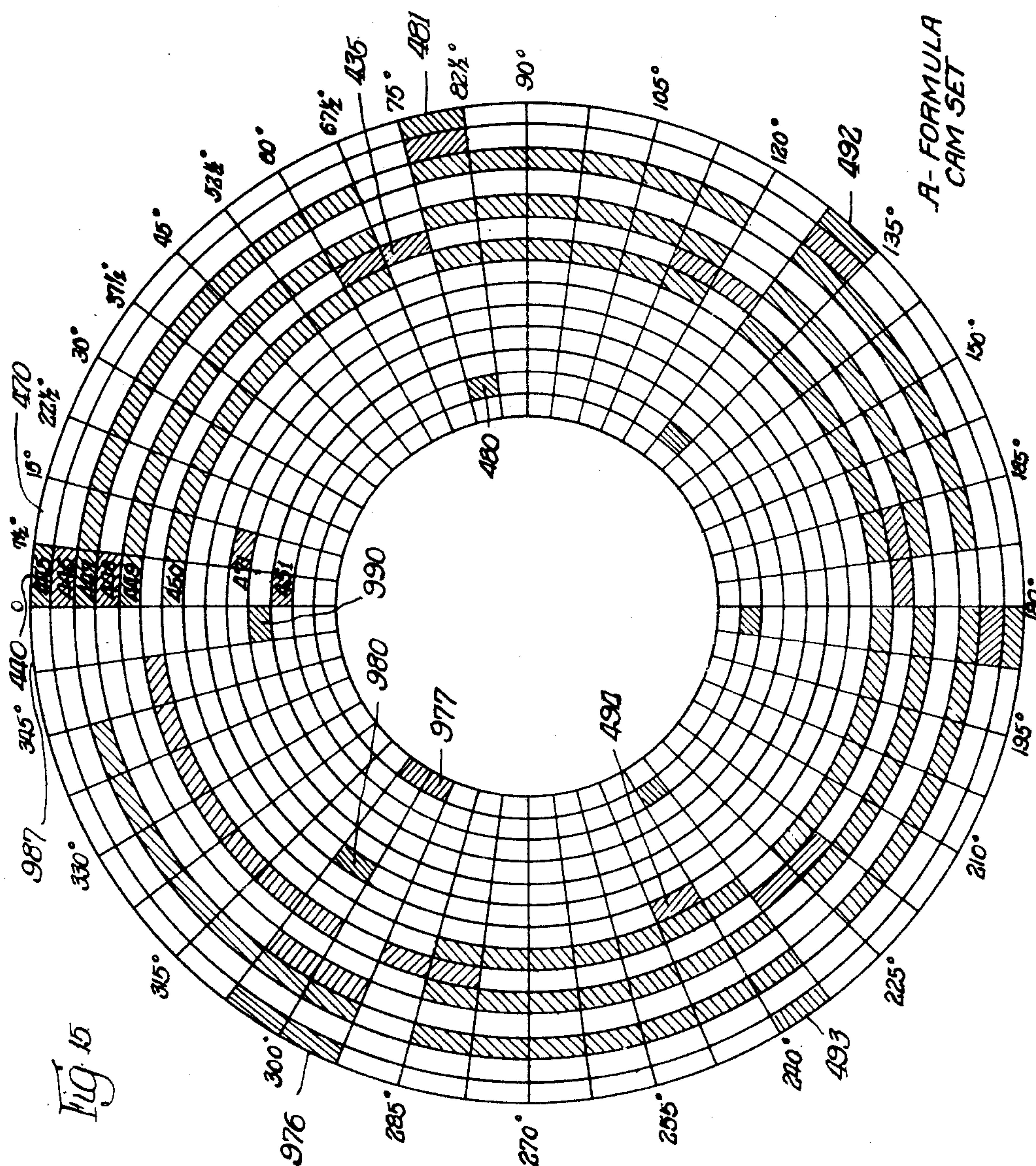
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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

Original Filed June 16, 1941 18 Sheets-Sheet 10



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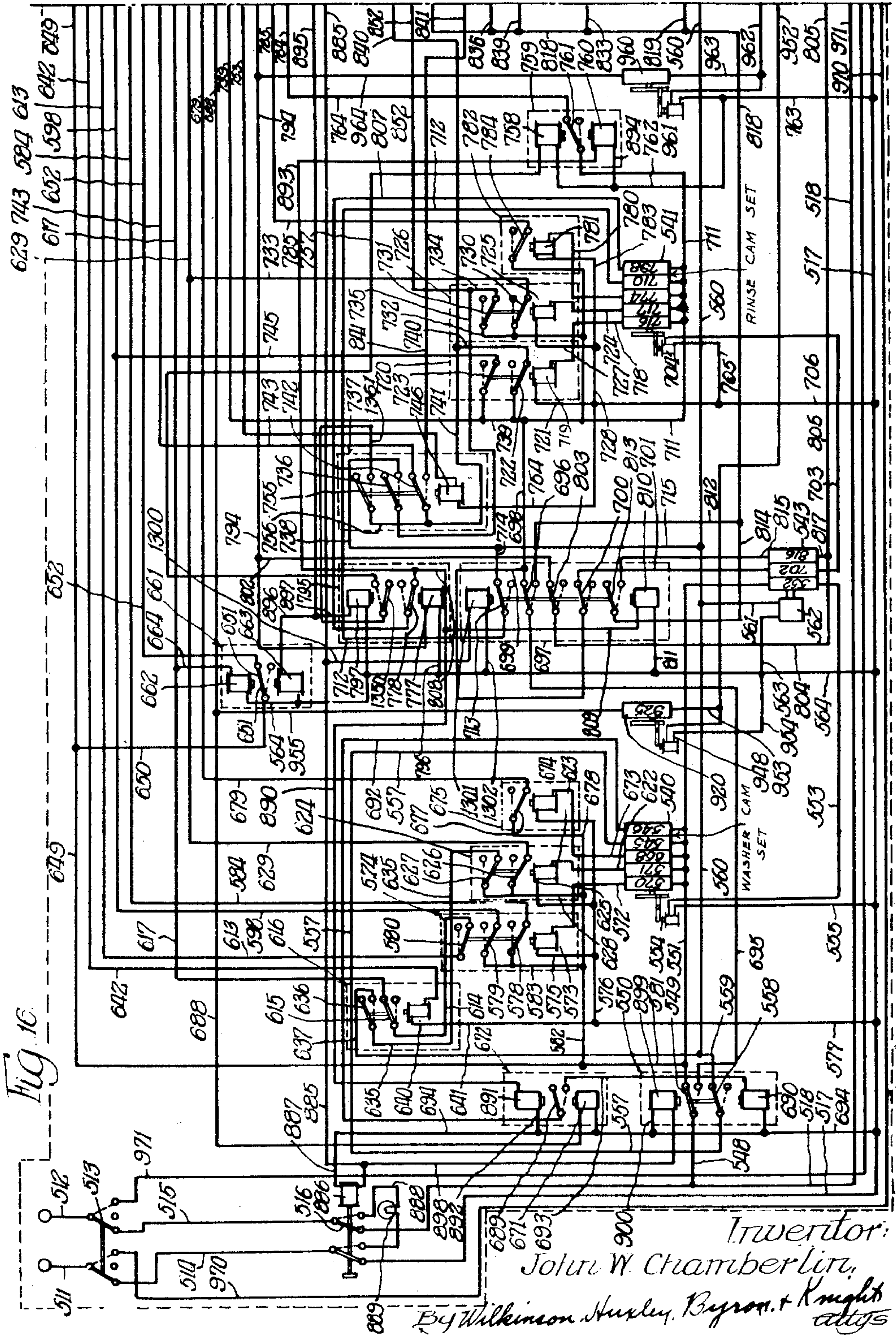
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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

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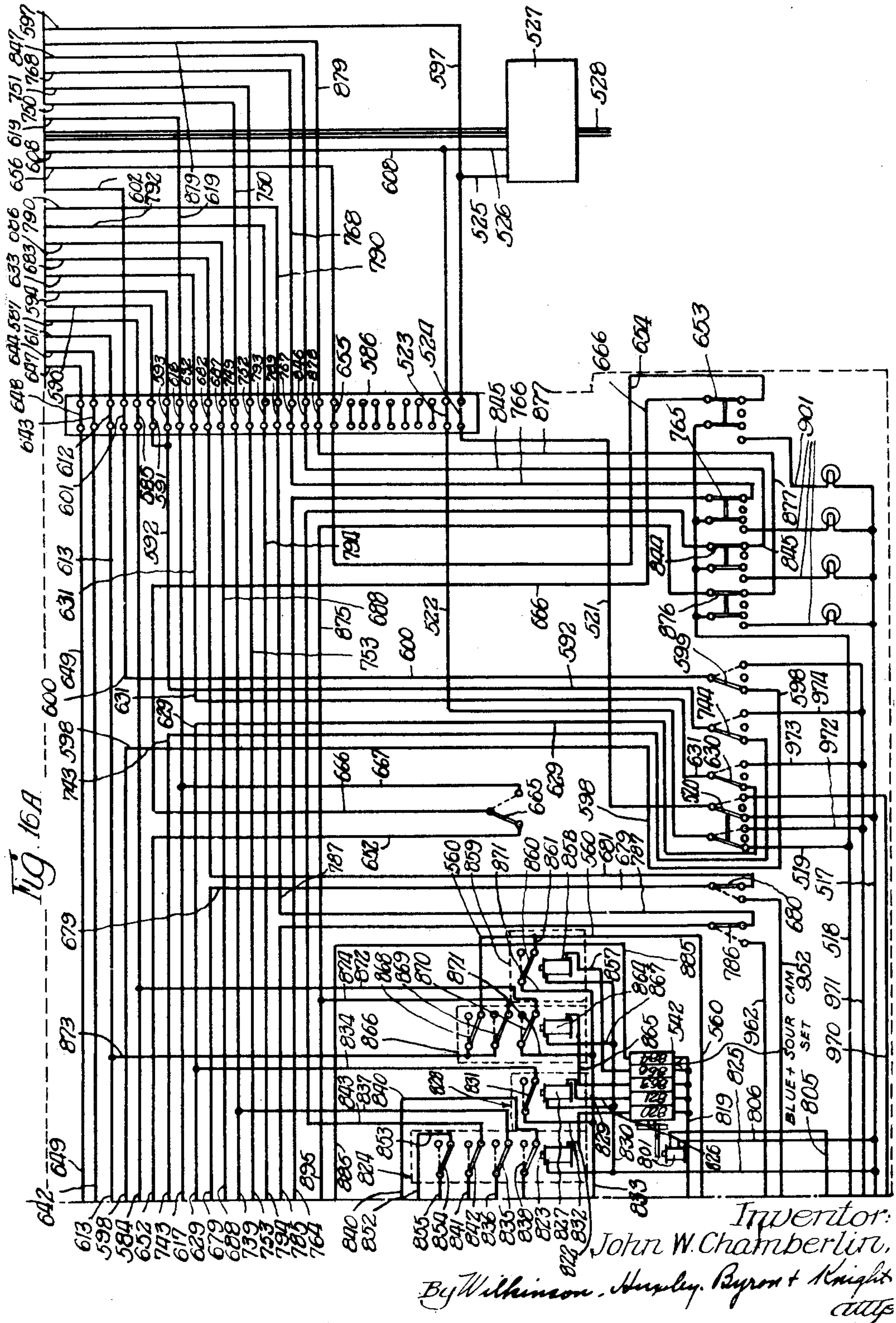
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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

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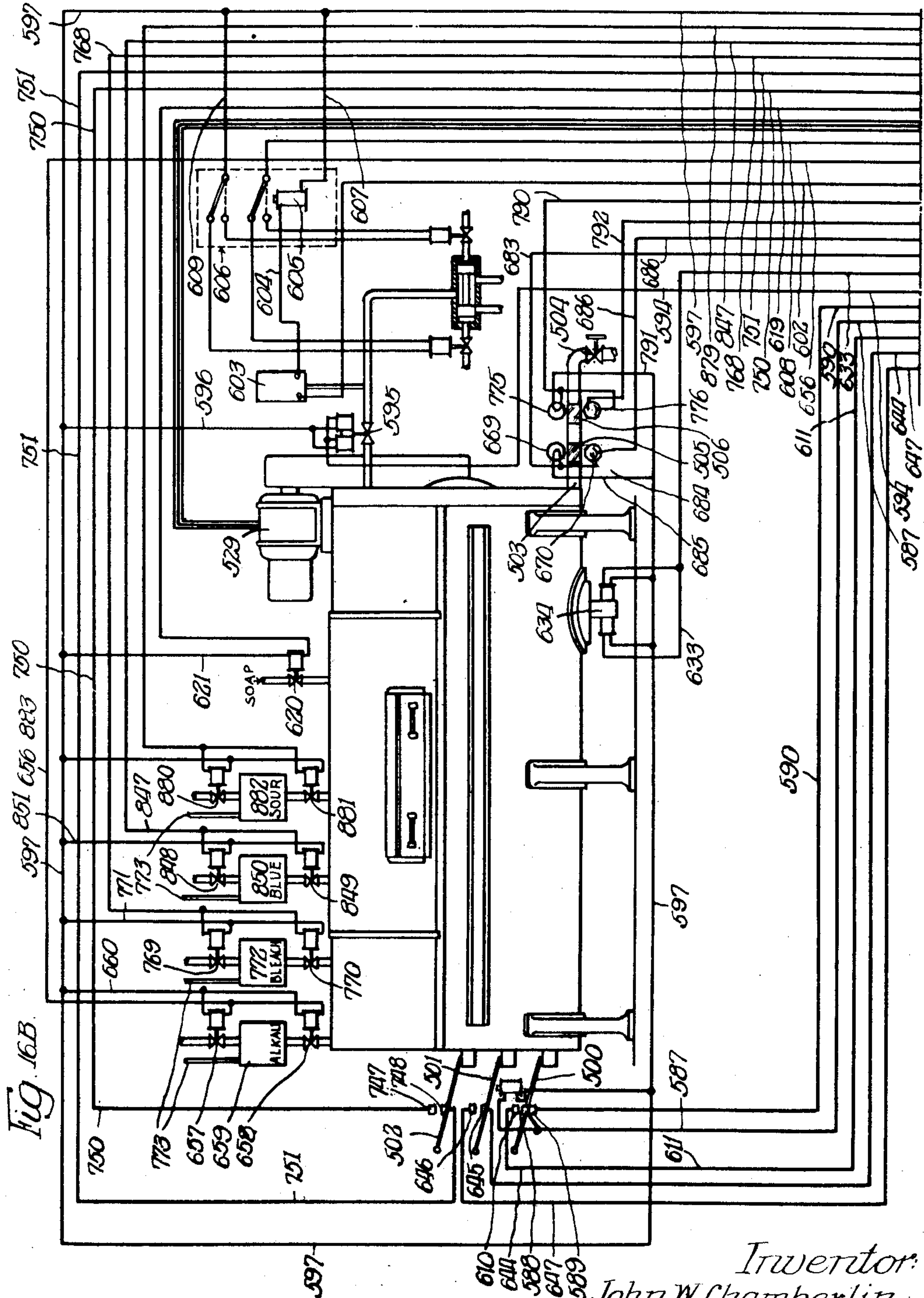


Fig. 16B.

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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

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Fig. 19

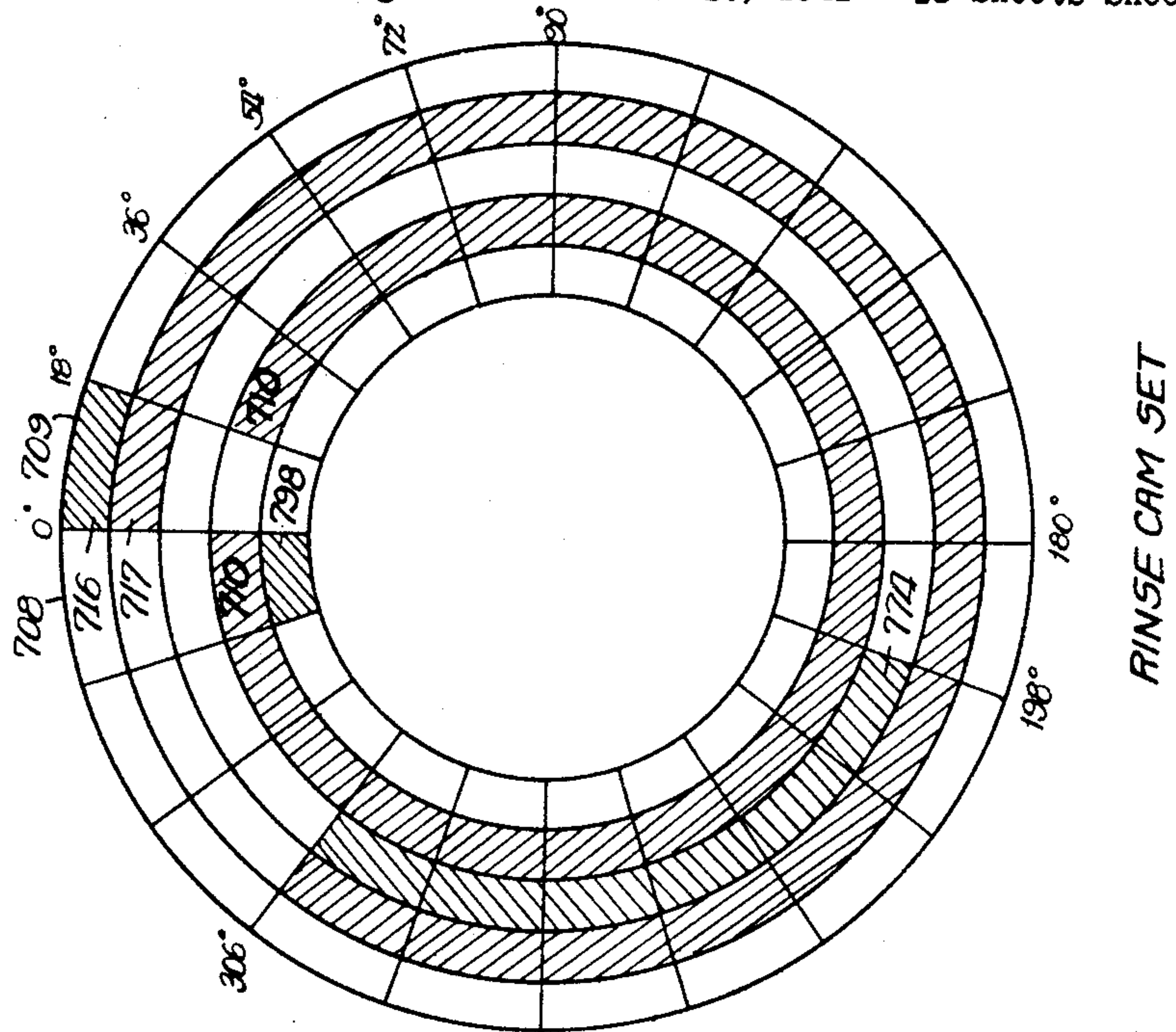
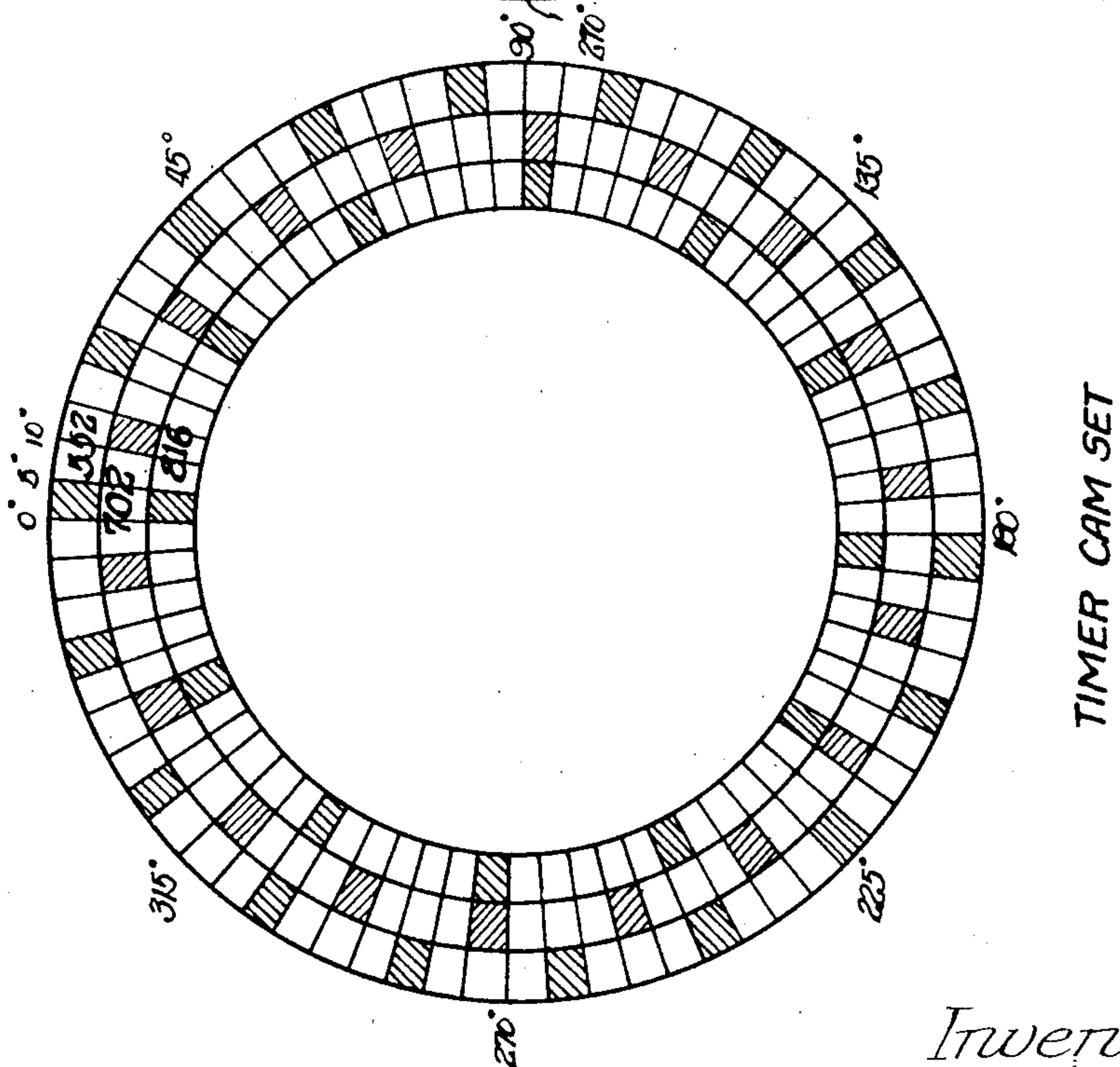


Fig. 17



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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

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Fig. 20

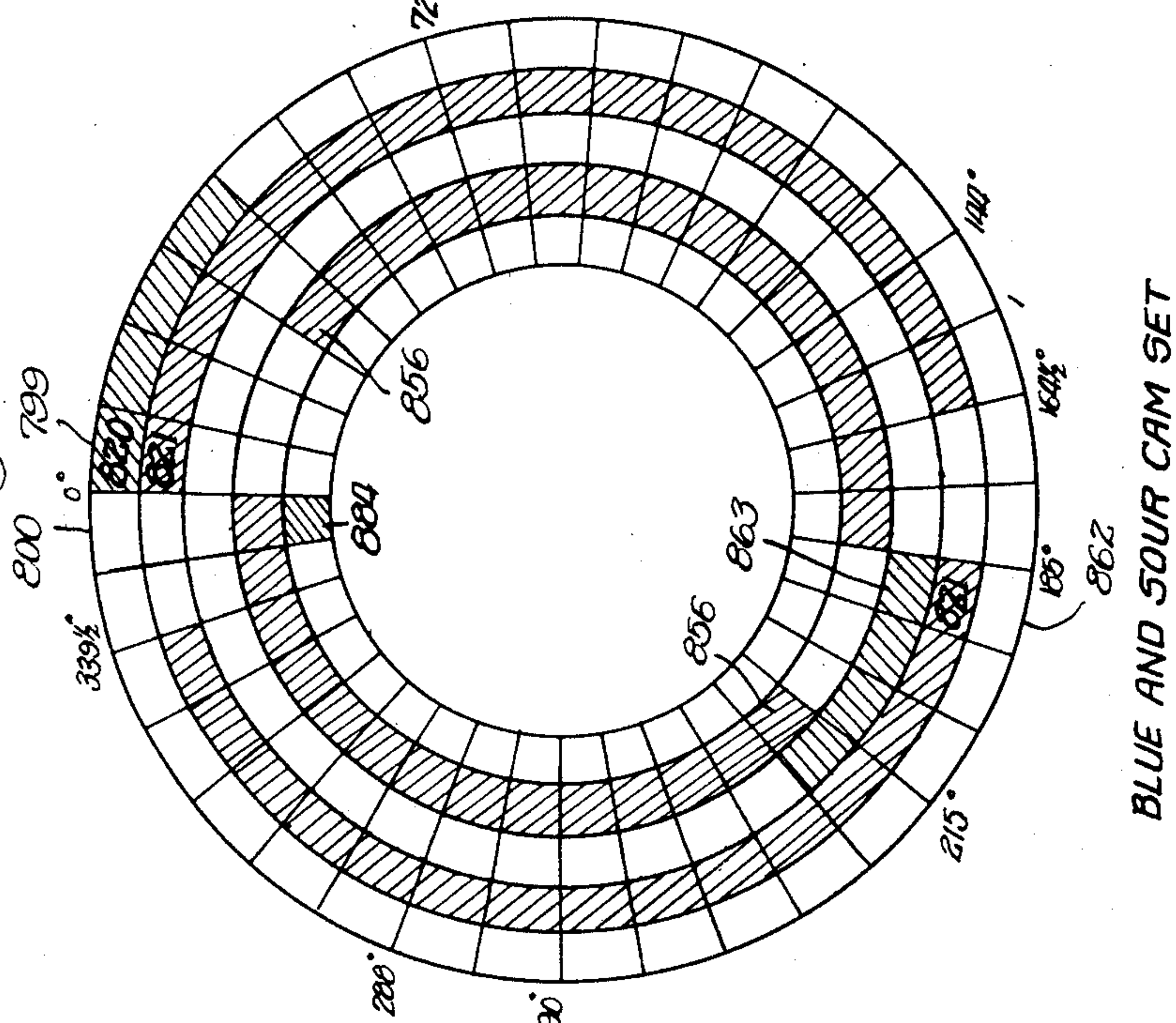
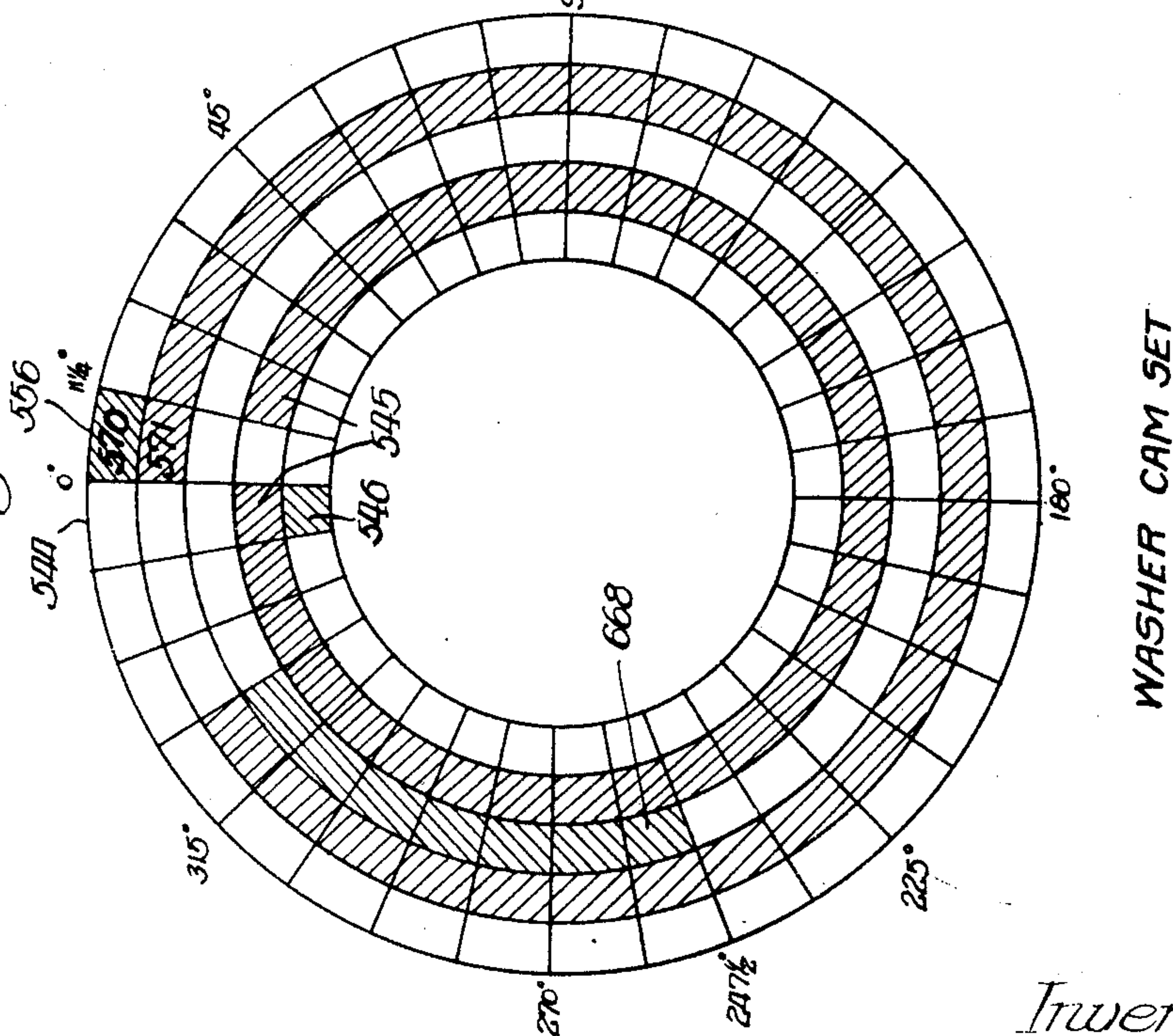


Fig. 18



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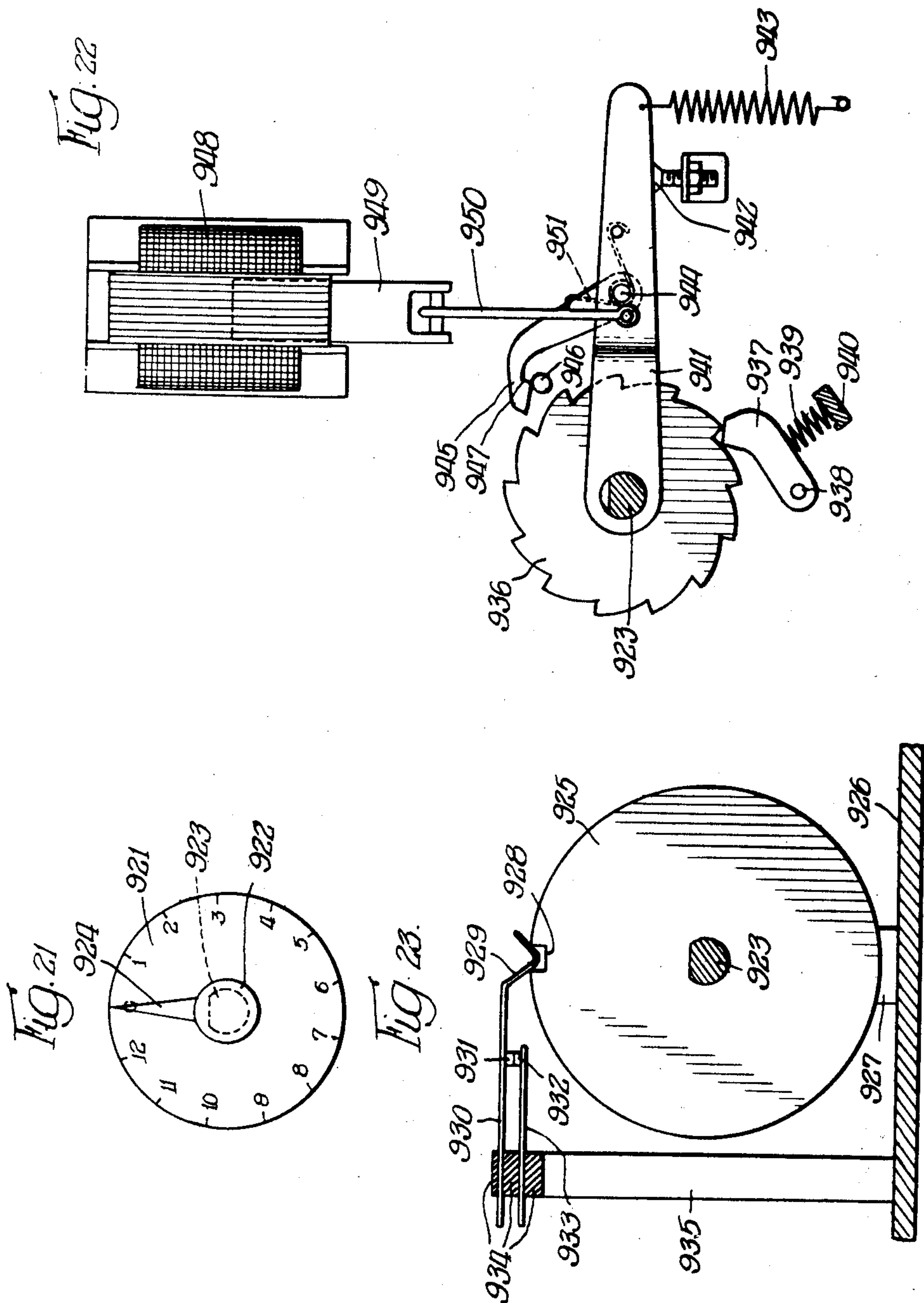
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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

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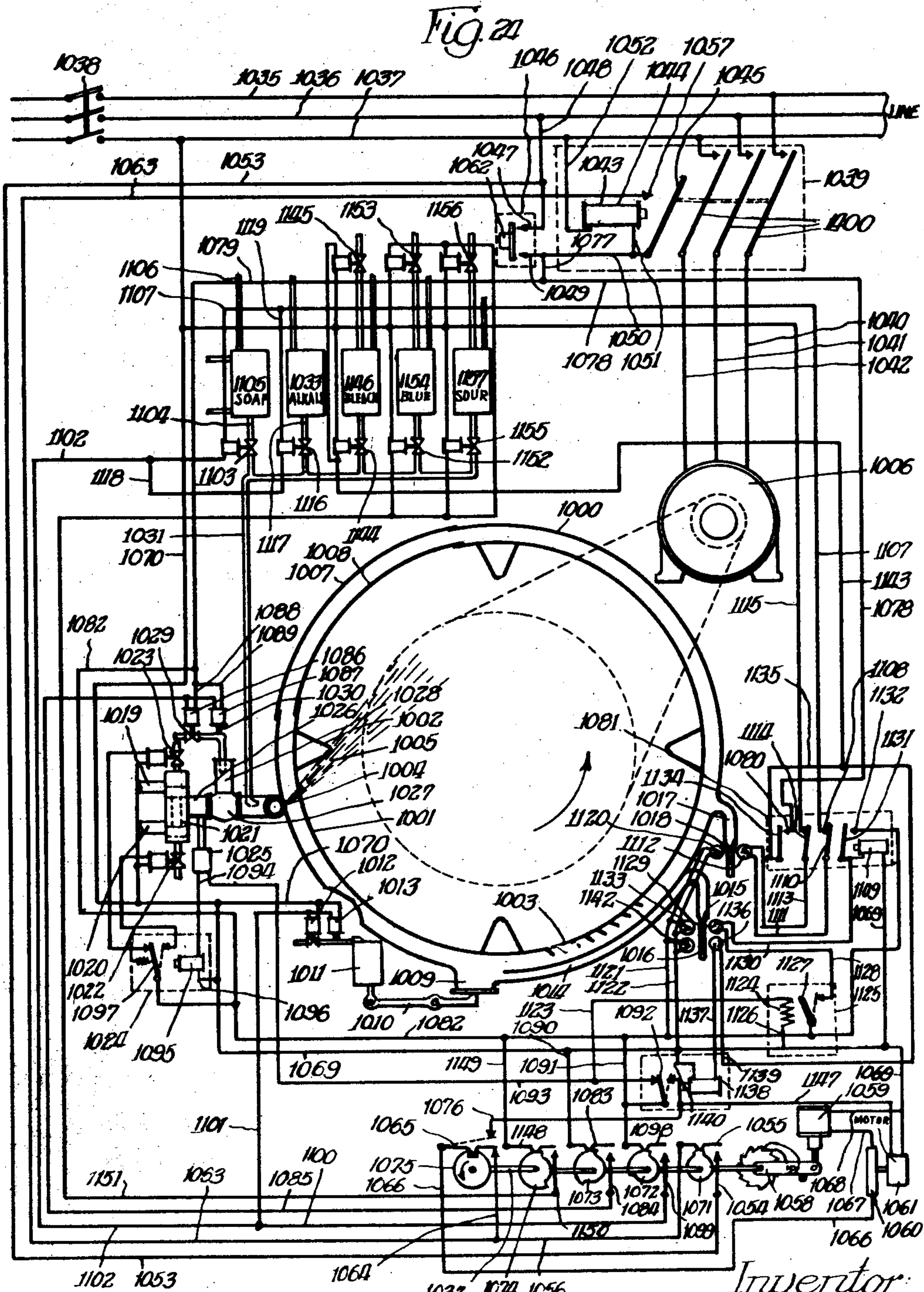


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Fig. 21



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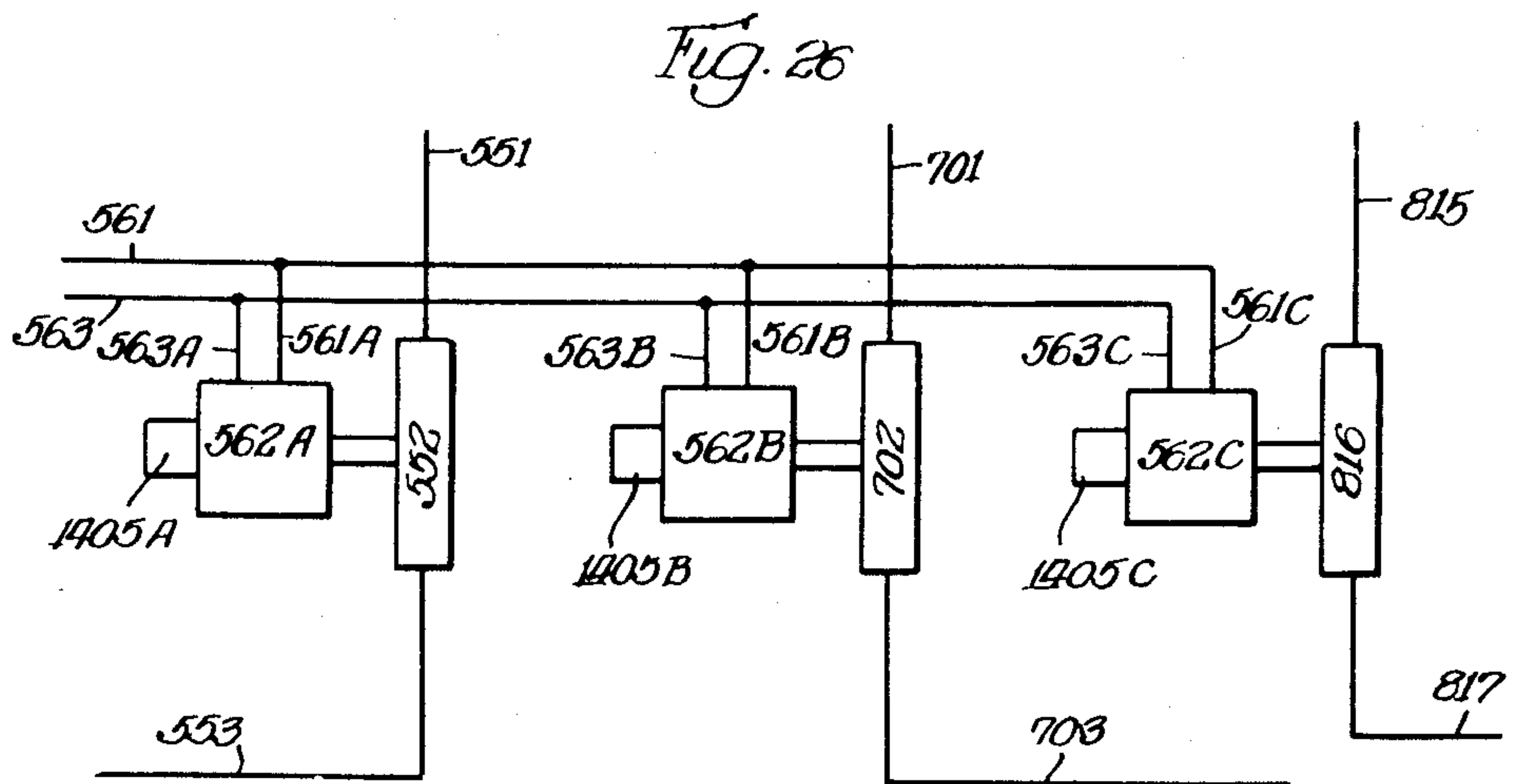
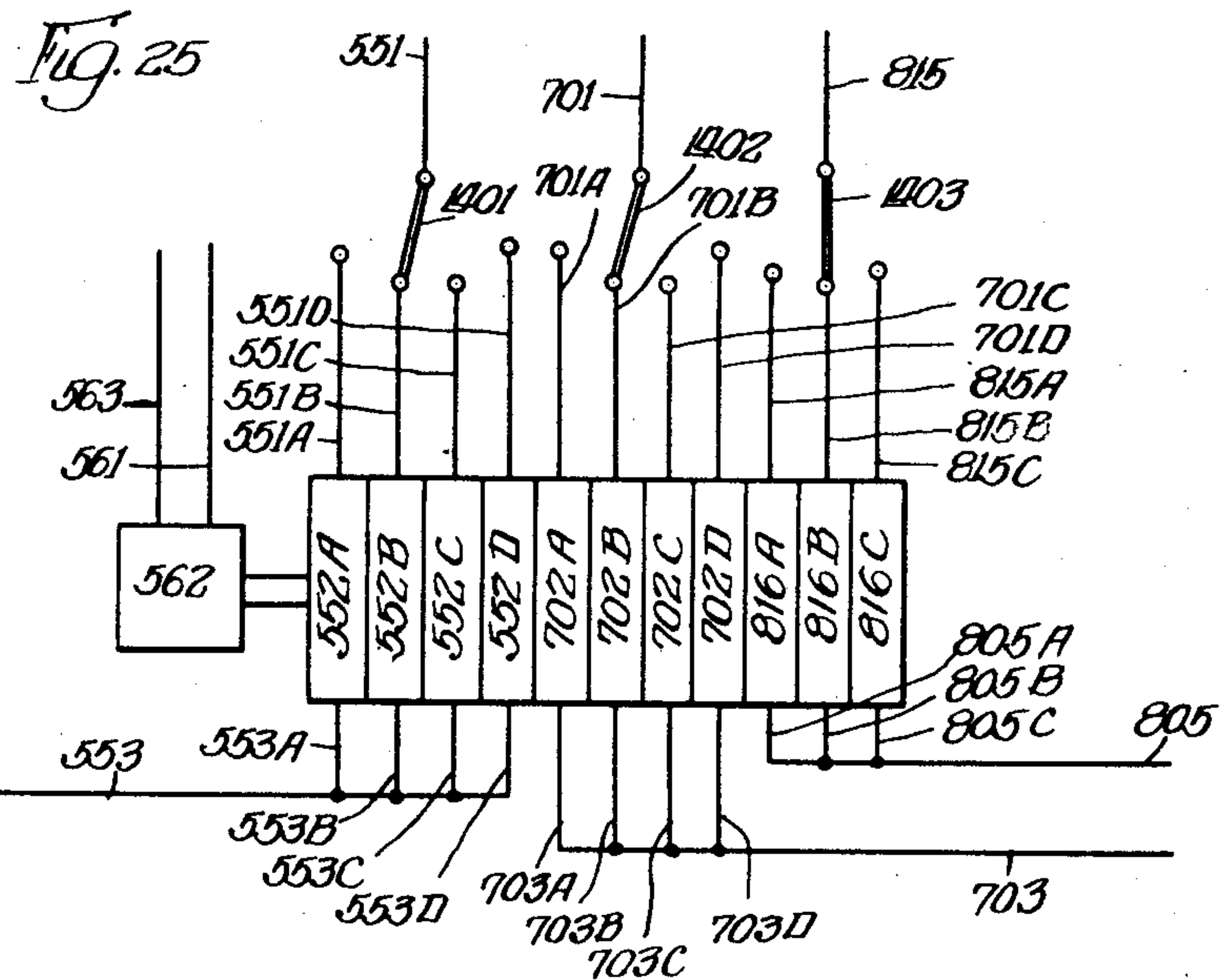
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WASHING MACHINE AND AUTOMATIC CONTROL MECHANISM THEREFOR

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UNITED STATES PATENT OFFICE

2,430,668

WASHING MACHINE AND AUTOMATIC
CONTROL MECHANISM THEREFOR

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Original application June 16, 1941, Serial No.
398,244. Divided and this application April
15, 1942, Serial No. 438,984

65 Claims. (Cl. 68—12)

1

This invention relates to a new and improved laundry machine and control mechanism, which is capable of automatically controlling various washing, bleaching, rinsing, bluing and souring treatments as may be desired, to the end of producing an improved washing result.

This application is a division of applicant's co-pending application Serial No. 398,244, filed June 16, 1941, in which is disclosed and claimed a new and improved process and various specific embodiments thereof.

The control mechanism of this invention is particularly adapted to perform a washing operation in which the washing liquid employed, or a characteristic portion thereof, is scientifically analyzed one or more times after the clothes and washing liquid has been brought together and, by such analysis, detecting a property of the analyzed liquid which according to predetermined standards is representative of the quantity or the quantity and character of the soil to be removed by and held in the washing liquid, and, further, automatically utilizing the detected property as a basis for or as the governing factor which automatically causes the selection, establishment or creation of a particular washing procedure or formula which is that preferred on the basis of predetermined standards to be the best adapted for the removal of the quantity or the quantity and character of the soil found to be present in each particular case.

By the use of this invention, each particular batch of clothes undergoing treatment may be analyzed or measured for soil content and thereafter subjected to a particular washing procedure which, according to certain predetermined standards, based on the soil analysis, is preferred for the need at hand, or is considered to be best adapted for the satisfactory removal of the amount of soil found to be present in each particular case.

This invention takes into account the fact that different or somewhat modified washing procedures should be employed for the best results when different batches of clothes containing different amounts or types of soil are being washed, and the further fact that the particular washing procedure employed should be selected, established or created on a scientific basis and should bear a close relationship to the quantity or quan-

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tity and character of the soil found to be present. Furthermore in providing a satisfactory washing procedure, the nature of the textiles and the dyestuffs on the textiles must be taken into account, so that the selected procedure must provide for protection of the materials washed as well as the removal of the soil therefrom.

Accordingly, the use of this invention involves as one step thereof an analysis of the washing liquid by which the amount or the amount and character of the soil present in any particular batch of clothes is made a guiding or controlling factor, and further involves the step of selecting, establishing or creating a washing procedure or formula which, according to certain predetermined standards, is best adapted for the production of the desired results. This invention also involves the further step or steps of completely washing the clothes by the particular procedure or formula thus selected, established or created.

Although this invention is not to be so limited, it will have special usefulness in the commercial laundry field where a relatively wide variation is found in the amount of soil existing in the clothes to be treated and where, according to present practice it is recognized that different procedures should be employed with different batches of clothes, depending upon the soil condition in each particular case.

It is known that the quantity of soil found in clothes to be laundered varies in amount and also that different batches of clothes containing different amounts of soil present different washing problems. This is especially true in the case of commercial laundries, and on this account it has been the practice in the past for laundries to classify the clothes to be washed into several categories according to the appearance of the soil therein, each of which would be referred to by characteristic designations, such as, for instance, light soil, medium soil, heavy soil, and extra heavy soil. It has also been the practice to subject the clothes of each class to a washing treatment which, according to the judgment of the laundry operator, was preferred for the problem in each particular case. According to this prior practice, however, such classifications have been made by mere visual inspection whereby the amount of soil was estimated by the appearance of the soil in the clothes, and as a result many

variations and errors have inevitably been involved on account of the differences which exist in the judgment of operators, characteristics of eyesight, light conditions, and many similar factors which are necessarily involved and are bound to seriously affect a visual classification method.

In addition, it has not been practicable in most cases for laundry operators to establish more than four or at most six categories for soiled clothes and consequently a wide range of variation has naturally existed in the amount of soil that may be present in similar loads of the same class. As all loads of the same class generally received the same treatment, it is apparent that the formula used in any particular case is rarely, if ever, correctly adjusted to the washing problem at hand.

Furthermore, this undesirable result has been increased by the fact that the classification of clothes is now largely a matter of guess work and as a result many items of clothing are not properly classified. This is particularly true in those instances where the soil content is such that the appearance thereof is close to the border line between two established classes. In addition to the foregoing, the very nature of the articles making up a batch of soiled clothes is such that the amount of soil present evades accurate detection when mere inspection is relied upon.

Insofar as it is known, no one, prior to this invention, has provided laundry machine control mechanism by the use of which the amount of soil in clothes could be detected, measured or determined on a scientific basis and, hence, it is thought that it has not been possible in the past to select or employ a particular washing procedure which was scientifically adjusted to and adapted for the removal of the particular amount of soil present in any given batch of clothes.

As distinguished from all prior art devices, the use of the invention here disclosed will supplement the classification method and will provide a soil analysis procedure by which the amount of soil present is detected according to reliable scientific principles and will further make available the results of such analysis for use as a guiding or controlling factor in the selection, establishment or creation of the washing procedure to be employed. In consequence, the washing procedure utilized will always be scientifically adjusted to the problem of removing the particular quantity and character of soil found in the clothes in each particular case.

Furthermore, the use of this invention will provide a new and corrective procedure which will make up for the errors which are now made by laundry operators in the original classification of clothes and will result in the employment of washing procedures or formulas which are properly adjusted to the requirements in each particular case. The total soil content as well as the character thereof in certain instances will determine the formula to be employed and in this way a correct and efficient washing operation is always realized.

For a full appreciation of this invention, it should be understood that soil which is to be removed from clothes by a satisfactory washing operation is made up of different types of substances which have different properties and characteristics, and which require different chemical activities for their satisfactory removal from the fabrics and their elimination with the washing liquid. The substances constituting the soil in the clothes may be roughly divided into three classes, which are:

1. Solids, which include all relatively inert materials such as carbon, silica and similar particles.

2. Adhesives or binding substances which include saponifiable oils, unsaponifiable oils, fatty acids, albumin, and various water soluble materials of which salts and sugars are examples. In addition, when hard waters are used, calcium and magnesium are present, usually in the form of stearates, which may be regarded as soil as they must also be removed from the clothes and held in and discarded with the washing liquid.

3. Dyes and stains of various types, such as rust, medicine, blood, etc.

It has been found as a result of experimentation that on the average the relationship between the quantity of adhesive or binding substances and the quantity of solids which make up the soil does not vary widely in different batches of clothes, and that this is generally true even though the adhesives and solid materials present were not originally deposited in the same ratio. This is probably explained by the fact that the binder or adhesive substances exhibit an affinity for solids, whereby the presence of a binder, upon continued exposure, will attract and pick up an additional quantity of solid material, with the result that in most instances the binder and the solids are found in the soiled clothes in somewhat the same ratio in the average batch which is presented to the laundry.

The quantity of dyes present in the soil will naturally vary, and it is found that these substances form tightly adhering molecular films which closely surround the fibers of the cloth. Certain dyes are removed with the aid of a bleach in the washing process, whereas others present a special removal problem, but as a rule these are present in such small relative quantities that their removal is not considered as a part of the main washing problem. Their removal, if effected at all, must be accomplished by the use of special spotters which will be selected according to the particular kind of dyes found in the clothes.

Adhesive agents of the soil, if they existed alone, would not be particularly difficult to remove, nor would it be particularly difficult to work out and remove the solid material alone. However, it is found that complete removal of both together is much more difficult, particularly after the soil has been allowed to stand for a sufficient period, in the presence of air, to permit oxidation to take place.

The removal or washing methods involve both chemical and mechanical treatments and, in practice, it is necessary to obtain penetration in order that the reagents in the washing liquid are brought into contact with the constituents of the soil and also to physically dislodge and free the solids and binding materials from the fibers of the clothes and hold them either in solution or in suspension in the washing liquid. The maintenance of the suspension is a further chemical problem which requires accurate and detailed control if redeposition of the soil is to be avoided. Insofar as the chemical reactions are concerned, the acids must be neutralized, the saponifiable materials must be saponified with alkali, all water soluble materials must be dissolved, and all unsaponifiable oils and greases must be emulsified. In addition, a colloidal suspension of all solid particles must be created through the action of the detergent, whereby the substances constituting the soil when once removed from the clothes are firmly and permanently held in the washing liquid and are thus prevented from being rede-

posited. It should also be recalled that the alkali employed has the further function of fortifying the soap and that such fortification is required in order that the soil-holding power of the soap is maintained throughout the entire period of each suds treatment.

For a complete understanding of the problem presented in washing clothes or similar articles, it should be known that the prolongation of the detergent or soap treatment beyond the initial treatment is required primarily for the removal of solid particles rather than for reactions of a pure chemical nature. It is now common practice to employ a plurality of successive suds treatments, the first of which is referred to as the "breaker" suds. The breaker suds is usually sufficient to effect the various chemical changes or reactions which are required in any particular laundry process, but the subsequent suds treatment is nevertheless required in order to remove solid particles which remain in the clothes after the initial breaker suds treatment is completed.

Inasmuch as a certain percentage of the solid particles remaining in the clothes are dark in color, the presence of such particles imparts to soiled or incompletely washed clothes a gray appearance which is known to all laundry workers. This undesirable appearance is referred to by various terms, such as "gray," "bad color," or "lack of whiteness," but irrespective of the term employed, the condition so identified is always the presence of solids remaining in the clothes which should be washed out. Improper laundry treatments have attempted to meet this problem by bleaching so as to minimize the visibility of the solids present, but a thorough and proper washing necessarily accomplishes the satisfactory removal of the solid particles including white particles as well as the darker visible ones.

Some comparison of the conditions encountered in actual practice may be obtained from the following data, showing the results of actual microscopic counts made in the laboratory. The solid particles present, as indicated in the following table, were estimated for the larger area on the basis of an actual count of those microscopically visible at 100 diameters. The table is further based on an average computation taken from 100 such readings. The findings are as follows:

	Particles per square inch
Clean ¹ -----	.0
A. I. L. ² -----	6,838.7
Light soil -----	32,258.0
Heavy soil -----	483,870.0

¹ "Clean" is here given as the theoretical zero. However, clean, new material fresh from a factory shows a solid particle content of approximately 10 particles per square inch.

² The degree of cleanliness here referred to is that of the "Whiteness-retention standards" of the "American Institute of Laundries."

It will thus be seen that proper washing procedures which serve to satisfactorily separate and remove the substances constituting the average soil in clothes, involve a plurality of different chemical reactions which must be carried out simultaneously in the same liquid bath, and that each reaction must accomplish its own particular function without, however, disturbing or interfering with the others, and that, in addition, a satisfactory suspension must be maintained at all times in order to prevent the solids removed from the clothes from being redeposited. The maintenance of the suspension referred to is extremely important for the reason that if the suspension once starts to break down a substantially com-

plete redeposition of the solids results. Such redeposition, of course, proceeds according to the known behavior of suspensions of this type, and dictates the necessity for safeguarding at all times against the possibility of overloading of the liquid suspension or, in other words, the necessity for accurately adjusting the character of the washing liquid more or less exactly on a scientific basis to the quantity or quantity and character of soil to be removed. As already shown, the reactions, though separate, are nevertheless interdependent insofar as the final suspension is concerned, as the chemistry of the suspension is susceptible to all changes occurring in the washing liquid, and, if efficiency of operation is to be realized and the waste of detergent and other reagents is to be avoided, an accurate adjustment of the relationship between each particular batch of clothes and the character of the washing liquid and procedure employed becomes a necessity.

This invention is further based upon the discovery that the soil present in clothes imparts to the washing water certain detectable or measurable properties or characteristics which vary in degree a determinable extent as the quantity of soil varies, and the further discovery that these variable characteristics will serve, in the average case, as reasonably accurate indications of the quantity or quantity and character of the soil present. For instance, it has been discovered that soiled clothes are generally acid and that the degree of measurable acidity which is imparted thereby to the washing water will serve as a reliable indication, under most conditions, of the degree of soil present.

Consequently, as a possible soil-detecting procedure which may be employed in practice of this invention, it is contemplated that the clothes to be treated may be immersed in and treated with a predetermined quantity of water and the acidity extracted from the clothes measured according to any known procedure such as, for instance, by determining the hydrogen ion concentration of the water. Readings of this type can be taken for each particular batch of clothes and the results thereof utilized as an indication of the amount of soil present, whereby clothes so treated may then be subjected to the particular washing procedure which is most accurately adjusted to the particular washing problem presented by the soil condition existing therein.

As another possible and alternative procedure, the quantity of acid present in the bath may be determined by titration with a suitable alkali. By this procedure the alkali may be introduced into the washing water with which the clothes are treated until the acid present has been neutralized. The result of such procedure is that the quantity of alkali thus employed will provide a scientifically acquired indication of the amount of soil present. The indication afforded by titration will be somewhat more exact than the pH reading method, in those cases where the soiled clothes contain appreciable quantities of fats, oils and other saponifiable material for the reason that a portion of the alkali so employed will be utilized in the saponifying reactions in addition to that which is required to neutralize the detectable acid present. Thus, the total amount of alkali used in such titration is closely indicative of the amount of saponifiable soil as well as the general acid character of the soil as a whole.

As a further analysis procedure, use may be made of the suds-forming behavior of detergents,

such as soap, or surface active agent, such as sulphonated alcohols. According to this method, the clothes and predetermined quantities of water, alkali and an amount of detergent are brought together. The soap should be added until a predetermined amount of suds is formed, or, for instance, until the suds reach a predetermined elevated level. When this point is reached, the quantity of detergent so introduced will serve as a reliable and scientifically acquired indication of the quantity and character of soil present. This method is based upon the fact that the presence of suds provides a reliable indication of the presence of free or unemployed soap as well as soap which has not been changed chemically by the soil present, and thus when a certain predetermined quantity of suds is produced it may be known that the quantity of soap required for their formation is proportional to the soil present, wherefore by comparing such quantity to certain predetermined standards based on tests, a reliable indication of the quantity or quantity and character of the soil may be had.

This procedure affords a still more accurate method of measuring the soil for the reason that the suds-producing characteristic of the detergent is not only varied with variations in the ratio of the quantities of soap and soil, but also to some extent with variations in the amount of available alkali present, which according to this method must be over and above that utilized in the saponification of the oils and fats present and that utilized in the neutralization of the acid in the washing bath.

In addition to the foregoing, the applicant has observed that a definite relationship exists between the amount of soil present in any particular batch of clothes and the degree of light, emanating from a light source of known intensity, which can be transmitted through a volume of predetermined depth of the wash water in which the clothes have been treated to a predetermined extent. This is true either with or without soap being present, although the presence of soap is preferred. In other words, it has been found that values expressed in degrees of light transmitted may be established by test, which serve accurately as indications of the amounts of soil present in the clothes to be washed. By the use of this procedure, it is possible to treat a given batch of clothes with a liquid which may comprise water alone or water and a detergent, either with or without alkali present, and after a predetermined degree of agitation to cause a volume of known depth of the washing liquid to occupy a position between a light source of known intensity and a light-responsive cell or meter, and in this manner to obtain a reading of the light-transmitting value of the interposed liquid. The values so obtained, by comparison to the standards previously established, will serve as an accurate indication of the degree of soil present in the liquid and also in the particular batch of clothes so treated. The same type of optical variations which are caused by the presence of solid particles also exists in turbid liquids such as those containing soap or other detergent or similar agents. Consequently, with light-responsive mechanisms the same mode of procedure may be utilized in rinsing operations that are employed for the removal of solids.

In addition to the foregoing analytical methods, it is contemplated that other methods may be used, such as, for instance, that of using reflected light instead of transmitted light, or that

of using light variations resulting from the diffusion of transmitted light. Furthermore, this invention could be practiced by actually separating the soil solids from a representative portion of the wash liquid and in this manner measuring the amount of soil per unit volume. Also, in addition to the direct method of reading light characteristics by the use of photo-electric cells, other light-responsive means may be employed, such as, for instance, photographic plates or similar light-responsive means.

In addition to the foregoing methods, it has been found that the presence of solids in the washing liquid has a measurable influence on the electrical conductivity of the liquid whereby measurements of the variations in electrical conductivity may be used as a basis for measuring the presence of solids as well as detergent and similar substances in the liquid.

It is an object of this invention to provide automatic control mechanism for laundry machines which is capable of carrying out automatically the various steps above referred to, which are necessary to a complete and satisfactory washing operation and which will, at the same time, provide a particular washing treatment which is best adapted for the removal of the quantity or quantity and character of the soil present.

For the purpose of illustrating this invention, various forms of automatic controls are hereinafter described which are merely illustrative of a wide variety of possible mechanisms, but which show practical controls by which the invention here described can actually be practiced.

In the following description, one type of control operates upon the principle of conducting an initial analysis after the clothes and the washing liquid have been brought together, and then automatically selecting one of a number of particular washing formulas according to the result of the original analysis. As a result of such selection, the washing procedure is then automatically conducted in accordance with the selected formula, with the result that the particular batch of clothes analyzed and treated is given the particular washing formula which is preferred, on the basis of the predetermined standards, for the removal of the quantity or quantity and character of soil present.

In another form of apparatus hereinafter disclosed, a somewhat modified mechanism for practicing this invention is illustrated, in that the analysis carried out involves the use of photo-electric cells which respond to the light-transmitting characteristics of the washing water and rinsing water, and in this manner indicates the amount of soil and soap present therein.

In the form disclosed in the drawings, the washing procedure involves an initial suds treatment of predetermined duration and an analysis of the washing liquid utilized in the initial suds operation. If the analysis indicates an amount of soil is present above a certain predetermined amount, the device automatically provides for a second suds operation. The washing water of the second suds is similarly analyzed automatically, with the result that the additional suds treatments are automatically provided for so long as the soil content shows a need for further washing. When, however, the analysis indicates that the clothes are clean, the mechanism automatically discontinues the suds operation and causes the clothes to be rinsed. The rinsing liquid is also analyzed photo-electrically for the detection of the presence of soap in the water, with the

result that successive rinsing operations are automatically provided for until the soap has been substantially entirely removed, on the basis of predetermined standards. After the rinsing has been completed, this device will then automatically provide for the desired bluing and sour treatments, and thereafter automatically shut off.

In still another form hereinafter illustrated, the process is practiced by what may be termed a continuous washing procedure but which likewise carries out this invention by conducting an analysis which controls the washing procedure according to the need therefor. In this illustrated form, the clothes may be subjected to the washing action of continuously inflowing water into which is introduced the desired proportion of soap. The clothes are constantly agitated, as, for instance, in a revolving drum, in such manner that the water and detergent in suspension comes in contact with and penetrates the clothes in a satisfactory manner to exert the desired washing effect. At the same time, however, the washing liquid is being constantly withdrawn from its association with the clothes and is being analyzed by photo-electric means for soil content. This may be determined by light-transmitting properties or light-diffusing properties as desired, but in any event the apparatus causes the washing procedure to continue until the dirt has been removed to the desired extent. When a predetermined degree of cleanliness is reached, the analyzing device automatically causes the introduction of soap to be discontinued, whereupon water alone is brought in contact with the clothes, thereby to produce a rinsing operation. In similar manner and by the use of a similar but different photo-electric detecting means, the rinsing operation is continued until the soap is substantially entirely removed. After the rinsing has been completed, this device will then automatically provide for the desired bluing and sour treatments and then automatically stop.

As a part of the foregoing procedure, this invention provides for the introduction of bleach to take care of certain of the foreign dyes which are usually found to be present. The bleach can be added to the last suds treatment or in the first rinse treatment. In the illustration here given, it is provided in the first rinse treatment, but it is only necessary that the bleach be employed in a liquid of high temperature and at a time when substantially no soil is present and under conditions of relatively high pH.

Reference will now be made to the specific devices disclosed by way of example, which may be better understood by referring to the accompanying drawings, in which—

Figs. 1, 1A and 1B collectively constitute a representation of a novel automatic control for a laundry machine.

Fig. 2 is a side elevational view of the washing machine proper with the control mechanism mounted thereon.

Fig. 3 is an enlarged cross sectional view of the washing machine dump valve together with the electrically controlled operating mechanism therefor.

Fig. 4 is an end elevational view of the mechanism shown in Fig. 3, as seen from the right-hand side thereof.

Fig. 5 is an elevational view, partly in cross section, of a switch operating diaphragm mechanism which is utilized in the control system of

Figs. 1, 1A and 1B in a manner hereinafter described.

Fig. 6 is a side elevational view, partly in cross section, showing a conventional water valve and also controls therefor. This valve is utilized in the water inlet pipe.

Fig. 7 is an elevational view in cross section of a normally open solenoid-controlled valve of a construction utilized in this mechanism, as hereinafter described.

Fig. 8 is an elevational view, in cross section, of a solenoid-operated, normally closed valve of a type utilized in this mechanism, as hereinafter described.

Fig. 9 is a side elevational view, partly in cross section, of a typical cam and switch assembly, by which the switch contacts may be controlled by means of the particular cams employed.

Fig. 10 is a plan view, partly in cross section, of the cam and switch assembly illustrated in Fig. 9, also showing the solenoid-operated ratchet mechanism for advancing the cams.

Fig. 11 is an elevational view of a panel of the control mechanism of Figs. 1, 1A and 1B showing six solenoid-operated ratchets hereinafter more fully described, together with various switch devices utilized in the automatic control.

Fig. 12 is a diagrammatic layout showing the shapes and relative positions of the six switch-operating cams which constitute the timer-cam assembly.

Fig. 13 is a diagrammatic layout showing the shapes and relative positions of the seven switch-operating cams which constitute the selector-cam assembly.

Fig. 14 is a diagrammatic layout showing the shapes and relative positions of the twenty switch-operating cams which constitute the analyzer cam assembly.

Fig. 15 is a diagrammatic layout showing the shapes and relative positions of the fourteen switch-operating cams which constitute the "A" formula cam assembly. All of the formula cam assemblies are not illustrated as they may have various shapes and positions as desired, but the illustration of Fig. 15 may be taken as illustrative of the type referred to.

Figs. 16, 16A and 16B collectively illustrate a washing machine and a modified control mechanism therefor.

Fig. 17 is a diagrammatic layout showing the shapes and relative positions of the three switch-operating cams which collectively constitute the timer-cam assembly utilized in the modified control illustrated in Figs. 16, 16A and 16B.

Fig. 18 is a diagrammatic layout showing the shapes and relative positions of the five switch-operating cams which collectively constitute the washing-cycle cam assembly utilized in the modified control illustrated in Figs. 16, 16A and 16B.

Fig. 19 is a diagrammatic layout showing the shapes and relative positions of the five switch-operating cams which collectively constitute the rinsing cycle cam assembly utilized in the modified control illustrated in Figs. 16, 16A and 16B.

Fig. 20 is a diagrammatic layout showing the shapes and relative positions of the five switch-operating cams which collectively constitute the blue and sour operating cam assemblies utilized in the modified control illustrated in Figs. 16, 16A and 16B.

Fig. 21 is an elevational view of the manual setting knob and dial which constitutes a part of the control mechanism illustrated in Figs. 16, 16A and 16B.

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Fig. 22 is an elevational view, partly in cross section, of the solenoid-operated ratchet mechanism which is capable of being set initially by the manual setting knob shown in Fig. 21.

Fig. 23 is an elevational view, partly in cross section, of the cam and associated contact switch, which is moved in one direction by the ratchet device of Fig. 22 and in the opposite direction by the manually operable knob of Fig. 21.

Fig. 24 is a diagrammatic representation of a washing machine and a control mechanism therefor of a further modified form which is characterized as performing what may be termed a continuous adaptation of this process, and by which the clothes are continuously washed until clean and subsequently are continuously rinsed until the soap is removed. This continuous treatment is then followed by separate blue and sour treatments, either together or separately; and

Figs. 25 and 26 are diagrammatic views of modified timing mechanisms which may be employed in the form of the invention shown in Figs. 16, 16A and 16B, as well as in the form shown in Figs. 1, 1A and 1B.

FIRST FORM

[Figures 1 to 15, inclusive]

WASHING MACHINE CONSTRUCTION

Machine proper

By referring particularly to Figs. 1B and 2, it will be observed that the washing machine here illustrated comprises a horizontally disposed cylindrical tank 30 mounted on a support 31 and in which is rotatably mounted a perforated washing cylinder 32 of conventional construction having ribs 33 and 34 disposed therein. The interior of the washer is made accessible by a suitable door 35 which extends along the upper front of the machine and is adapted to slide to open position in the usual way. The door is preferably provided with a soap chute 36 having a pivoted top 37. The washing cylinder 30 is further provided with a dump valve, shown generally at 38 but more specifically illustrated in Fig. 3. The water inlet pipe 39 is provided at the rear of the washing cylinder as well as the additional pipes 40, 41, 42, 43 and 44. These last five pipes are for the introduction of alkali, sour, blue, bleach and soap, respectively, in a manner hereinafter described.

Drive mechanism

The washing cylinder is rotated by power in the conventional manner, such as by means of a gear 45 located at one end thereof in position to mesh with a pinion 46 which is driven by means of a pulley 47, belt 48 and motor 49. The mechanism thus far described is of conventional construction, except for the pipes 40 to 44, inclusive.

The control for this washer is preferably mounted above the washer on a pedestal 50 supported by suitable means above the washing cylinder, and is preferably enclosed within a casing 51 which presents a panel 52 in the front thereof for mounting control knobs and the like in position accessible to an operator standing in front of the machine.

Dump valve

The dump valve 38 is illustrated in Fig. 3 and comprises a collar member 55 having an annular lower edge forming a seat against which the pivoted valve member closes. The valve member proper consists of a disc-like plate 56 having a

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cooperating member 57 and a suitable gasket 58, held by means of the screw 59. The plate 56 is provided with a downwardly extending projection 60 which rests within the opening of the collar 61 formed on the end of the operating lever 62. The operating lever is pivoted as at 63 on the shaft 64. This lever is provided with an upstanding lug 65 which serves as a mounting for the compression spring 66, the front end of which is held by a similar lug 67 carried by the foot treadle lever 68. The foot treadle 68 is also pivoted on the shaft 64 and is adapted to impart a closing movement to the valve when the outer end thereof is moved downwardly, and an opening movement when the outer end is moved upwardly. The opening movement is imparted to the valve lever 62 through a stirrup or strap 69 which underlies the end 70 of the valve lever. The foot treadle 68 has a tension spring 71 connected thereto, the upper end of which is connected as at 72 to a part of the frame 73. This spring normally tends to open the valve.

Dump valve operating mechanism

Mounted on the frame 73 as by means of the stationary shaft 74, is a fluid cylinder 75 having an inlet opening as shown, connected to an inlet valve 76. Mounted within the cylinder is the piston 77 which operates the piston rod 78 which is connected to the foot treadle 68. This connection is effected by passing the piston rod through a slot 79 and holding it in position by means of the pins 80 and 81, respectively.

As shown in Fig. 4, the inlet valve 76 serves to connect the cylinder with a source of fluid pressure, such as water, by means of the pipe 82. The valve 76 is a normally closed valve and may be of the construction illustrated in Fig. 8. In addition, an outlet valve 83 is provided for the operating fluid, which is connected to an exhaust pipe 84. This valve 83 is a normally open valve and may be of the construction illustrated in Fig. 7. As hereinafter described, the operating solenoids of these valves are electrically interlocked so that when one valve is open, the other is closed. Inasmuch as the valve constructions shown in Figs. 7 and 8 are of conventional designs, it is not thought that a detailed description thereof is required, other than to state that the plunger 85 and the valve member 86 of the valve 76 are restored to normal position by gravity, and the valve is opened by the action of the solenoid lifting the plunger and the valve member. In the normally open valve 83 of the type shown in Fig. 7, however, the plunger 87 normally occupies a position above the solenoid and is held in such position by means of the coil spring 88 whereby the valve member 89 is held open. In this case, the solenoid acts to lower the plunger 87 and thereby permit the valve member 89 to be seated when the valve is to be closed.

Water feeding mechanism

Referring now to Fig. 6, the water inlet valve is of any desired construction, as shown generally at 90, and has extending upwardly therefrom the valve operating stem 91. This valve is a normally closed valve in which the valve member is held in seated position by means of a spring 92 which is mounted in a fluid operating cylinder 93 which also contains a piston 94 connected to the valve stem above the spring. The fluid cylinder and piston construction are adapted to be operated by fluid pressure which enters through

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an inlet pipe 95 controlled by a valve 96 and is adapted to be discharged through an outlet pipe 97 controlled by a valve 98. The solenoid 99 associated with the valve 96 may be similar in construction to that shown in Fig. 8, which illustrates a normally closed solenoid-operated valve. The solenoid 100 associated with the valve 98 may be similar in construction to that shown in Fig. 7, which illustrates a normally open solenoid-operated valve.

Mechanisms for feeding soap, alkali, bleach, blue and sour

In the construction shown in Fig. 1B, the pipes 40, 41, 42, 43 and 44 are provided, respectively, with the solenoid-operated valves 101, 102, 103, 104 and 105, each of which is a normally closed valve of the type illustrated in Fig. 8. The pipe 40 connects with a measuring tank 106 which is adapted to contain a predetermined quantity of alkali. The pipe 41 leads into a measuring tank 107 which is adapted to contain a predetermined quantity of sour. The pipe 42 communicates with a tank 108 which is adapted to contain a predetermined quantity of blue. The pipe 43 communicates with a measuring tank 109 which is adapted to contain a predetermined quantity of bleach. These four tanks are supplied, respectively, by pipes as shown in Fig. 1B, which, include, respectively, valves 110, 111, 112 and 113. The last-named valves are normally open solenoid-operated valves and may be of the construction illustrated in Fig. 7.

Temperature control mechanism

As best shown in Fig. 1B, the water inlet valve 90 communicates with a pipe 115 which in turn connects with a piston type mixing device 116 of cylindrical construction, provided with a slidable dumbbell piston 117. This device is connected to a source of cold water 118 and to a source of hot water at 119. At its opposite ends, suitable connections 120 and 121 are provided to sources of fluid pressure, such as water, so that the dumbbell piston may be moved in the cylinder under the influence of the fluid pressure so as to provide any desired mixture of hot and cold water. The operating pressures supplied through the pipes 120 and 121, respectively, are controlled by means of solenoid-operated valves 122 and 123, respectively, both of which are normally closed valves of the type illustrated in Fig. 8. The solenoids for these valves are operated under the direct control of a thermostat 124 which may be manually set to give any desired temperature. The thermostat communicates with the mixed water line 115 through a communicating pipe 125.

Pressure diaphragm control mechanism

In addition to the foregoing, the washing cylinder 30 is provided with two diaphragm mechanisms of the type illustrated in Fig. 5. This illustrated diaphragm device is mounted on top of an upstanding pipe 130 which is in direct communication with the interior of the washing cylinder. The upper edge of the pipe 130 is fixed at a predetermined level or height with respect to the interior of the washing cylinder. Diaphragm mechanisms of this type are represented diagrammatically in Fig. 1B at 131 and 132, respectively. Mounted on top of the pipe 130 is a movable diaphragm member 133 which is fixed to the edge of the upstanding pipe by means of the holding collar 134, and anchoring bolts 135. The diaphragm is of such construction that the

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middle portion thereof is adapted to have a predetermined up and down movement under the influence of pressure exerted thereon from below and its normal bias in a downward direction. Attached to the middle of the diaphragm on the upper side thereof is an iron core 136 to which is attached one end of the lever 137 which is pivoted at 138 to a stationary part of the device. The lever 137 has its opposite end extended upwardly as at 139 in a position for engagement with the operating plunger 140 of an electrical switch or similar mechanism represented at 141. Mounted on the upper end of the pipe is a bracket 142, which serves to support an electric magnet 143 which is adjustable as to height by means of the mounting screw 144 which passes through the bracket and is capable of being locked in adjusted position by means of lock nuts 145. This mechanism is designed to respond to the upward pressure of water or suds below the diaphragm so that upon reaching a sufficient pressure, the iron core 136 is attracted to and held by the core of the magnet 143, in which position the lever 137 holds the operating plunger 140 of the switch 141 in the desired position. When, however, the pressure is released from below the diaphragm, and the magnet 143 is deenergized, the diaphragm exerts its normal bias and resumes its downward position as shown, and permits the switch or similar mechanism 141 to resume its former position as illustrated.

Another characteristic of this type of diaphragm device is that the action of the magnet effects a quick and positive movement of the switch for the reason that the magnet quickly draws the iron core to its maximum upward position at the instant a pressure is exerted which is sufficient to bring the iron core 136 within the active sphere of the magnet. In other words, the mechanism does not depend on the pressure below the diaphragm to raise the core of the diaphragm to the height of the final upper position. As previously stated, two diaphragm-operated switches of the type illustrated in Fig. 5 are employed at different predetermined heights for purposes and for operation in a manner hereinafter more fully described.

AUTOMATIC CONTROL MECHANISM

Cam set construction

The electrically operated control mechanism will now be described. As particularly illustrated in Figs. 1 and 1A, the control mechanism here illustrated employs a plurality of multiple cam and switch units which are hereinafter referred to as the selector 150, the analyzer cam set 151, the formula A cam set 152, the formula B cam set 153, the formula C cam set 154, and formula D cam set 155. Each of these cam sets is constructed in the general manner shown in Figs. 9 and 10, and comprises a shaft 160 having a straight side 161 on which are non-rotatably mounted, in spaced relationship, a plurality of operating circular cams 162 made of insulating material. Each of these cams has its own particular shape provided by notches 163, so as to provide high and low edge areas for imparting an up and down movement to the spring arms, such as the spring arm 164 of the contact switch 165. The spring arm 164 has a depending end which rides in engagement with the edge of its particular cam disc, and the arm is so constructed as to exert a spring pressure downwardly so as to make contact when permitted to do so by the cam.

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Each cam set is provided with an upstanding support 166 on which is mounted an insulating member 167 which serves to support the spring arm 164 and the cooperating arm 168. The actual contact points are shown at 169 and 170, respectively. This construction is representative of the contact switches and cam assemblies for all of the cam sets here employed.

The shaft 160 of each cam set is provided with a ratchet having a plurality of teeth and a locking pawl and an associated lever which is given a driving impulse by a solenoid. The particular ratchet and lever construction for each of the various devices varies according to the need in each particular case, as is best illustrated in Fig. 11. The selector is shown in the upper right-hand corner of Fig. 11, and has a ratchet 171 driven by a spring-pressed pawl 172 carried by the lever 173. This lever is actuated by the reciprocation of the plunger 174 of the solenoid, to which it is connected by the link 175. The lever is returned to normal position by means of a spring 176 where it is arrested by means of an adjustable stop 177. The advanced position of the ratchet at any particular moment is held by means of the spring pressed locking pawl 178. The other ratchet devices shown in Fig. 11 are similar in construction and will not be described in detail herein. It will be noted, however, that each ratchet has a particular number of teeth and a lever of particular length, the purpose of which will be hereinafter more specifically pointed out.

Timer

In addition to these cam sets, this control mechanism employs a timing device 180, shown in Fig. 1, which comprises a plurality of cams and associated contact switches of the type illustrated in Figs. 9 and 10. The cams, however, are driven directly by a motor 181 instead of by the solenoid operated ratchets above referred to.

Electrical circuits

The electrical circuits of the control device will now be described.

Power for machine motor

The main power line which drives the washer motor is shown at 200 at the right-hand side of Fig. 1A which leads into a box 201 in which is mounted a relay switch (not shown) which is controlled in the manner hereinafter described. This box may also contain reversing mechanism for reversing the direction of rotation of the motor in a manner which is now conventional in this art. This invention is not to be limited, however, to the reversely driven washing machine, as it applies equally well to the unidirectional washers.

Control of motor circuit

Any suitable relay for starting the motor and located in box 201 may be energized through lines 202 and 203 which connect through the dual switch 204 with lines 205 and 206, respectively. These lines in turn are connected with an interlocking relay switch 207 shown at the extreme left-hand side of Fig. 1. The opposite contacts of the switch 207 connect with a main source of current represented at 208, 209. A manually operable switch 210 may be inserted in the line to serve as an emergency cut-out when automatic control is in operation, and also as a means for disconnecting the automatic control altogether

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and substituting therefor certain manually operable switches as will be later explained.

STARTING WASHING OPERATION

Manual movement of selector

In order to start a washing operation, the desired quantity of clothes are placed in the washing machine and the lid 35 thereof is closed in the usual way. Thereafter, the manually operable knob 212 mounted on the front panel 52 of the control box (see Fig. 2) is turned by the operator to a position marked "Start." This knob 212 is fixed to the shaft 160 of the selector 150, and its clockwise rotation will cause a corresponding rotation of the shaft 160 whereupon the selector cam set is moved to that position where the segment 213 (see Fig. 13) is brought into engagement with the spring fingers of the contact switches associated therewith. This results in three contacts being made as represented by the cam notches 214, 215, and 216, respectively. These same reference numerals have been placed in corresponding positions on the diagrammatic representation of the selector shown in Fig. 1, and thus will serve to denote the contact switches themselves.

As a result of closing contact switch 215, the starting coil 217 of the interlocked starting relay is energized through lines 996, 997 and 998, whereby the switch 207 moves to "On" position. As previously pointed out, this energizes the relay in box 201 and connects the motor 49 to the main source of current 200 through connecting lines 218. The motor thus starts to operate either in a unidirectional manner or in a reversing manner according to whether or not reversing mechanism is employed. This motor in turn imparts a corresponding motion to the rotating drum of the washing machine.

Initial movement of analyzer cam set

The closing of the interlocked relay switch 207 also causes current to pass from line 206 through line 220 and bus-bar 221 and into contact switch 222 of the analyzer cam set which already occupies a position to close the contacts associated therewith (see Fig. 14). Thus, the current passes through the analyzer switch 222, into line 223 and into the contact switch 214 of the selector cam set. As previously described, however, switch 214 of the selector cam set was closed by the initial manual movement thereof, whereupon a connection is completed through lines 224 and 225 to the solenoid 226 of the analyzer cam set 151. The other connection for the solenoid 226 is made through lines 227 and 228 to the other current line 205.

This action causes the solenoid 226 of the analyzer cam set 151 to move one tooth space of the ratchet mechanism designated generally as 230, shown in the lower left-hand corner of Fig. 11. This movement of the analyzer cam set one tooth space causes the contact switches associated therewith to become free from segment 231 and to engage segment 232 (see Fig. 14). By this movement contact switch 222 of the analyzer cam set is broken, whereby the circuit just described for operating the solenoid 226 is likewise broken.

Conditioning selector cam set solenoid circuit

It should be noted from Fig. 13 that the original manual movement of the selector has also closed contact switch 216 of the selector cam set which is connected in a circuit which is employed for energizing the selector solenoid, but as this cir-

cuit is broken by the analyzer contact switch 245, as hereinafter pointed out, the solenoid of the selector cam set 150 is not energized at this time.

As more clearly shown in Fig. 14, the movement of the analyzer cam set from segment 231 to 232 causes a number of contact switches to be closed, namely, those numbered from 235 to 246, inclusive. As shown in Fig. 1, each of the switches 235 to 243, inclusive, is connected on one side through the bus-bar 221 and line 220 to the main current line 206.

Operation of water feed mechanism

The closing of contact switch 235 causes the normally closed water valve 90, shown in Fig. 1B, to be opened so that water can flow into the washing machine. This is accomplished by energizing the two solenoids 99 and 100 (shown in Fig. 6) of the solenoid-operated valves 96 and 98, respectively, which control the fluid pressure to the piston 94. To effect this result, the current is passed through contact switch 235 into line 247, through the terminals 248 of the terminal bar 249 (shown in Fig. 1A) and thence through line 250 to the single pole, double throw diaphragm-operated switch designated generally as 251. At the time this occurs, this switch will occupy the position illustrated in Fig. 1B, or in other words, in the position established when the fluid pressure diaphragm (see Fig. 5) is down, that is to say, uninfluenced by an internal lifting pressure. As a result, the contacts 252 are closed and hence the current from line 250 passes on through line 253 to terminals 254 of the terminal bar 249. From this point the current flows into line 255, back through the terminal bar at terminal 256, and thence through line 257 to the solenoids 99 and 100, respectively, which are connected in parallel. The other sides of the solenoids are connected through line 258 to line 202 which, as previously pointed out, is connected through terminal 234 and switch 204 to the other current line 205.

The wiring diagram may be more readily understood when it is known that the terminal bar 249 represents a division between the connections which are contained within the control box 51 and those which lie externally thereof. More specifically, all of the elements and connections therefor which lie within the dotted lines 260 in Figs. 1 and 1A are preferably mounted within the control box. It will thus be seen that all of the devices which are electrically operated by the control mechanism are connected thereto by wires which extend into the control box through the various terminals on the terminal bar. It will also be noted that some of the internal wires have been extended to the terminal bar to facilitate testing.

It is apparent that the opening of the water valve 90 by the control mechanism just described causes the water to flow into the washing machine. The water will continue to flow until it is automatically shut off by the diaphragm-operated switch 251 in a manner hereinafter described in detail.

Operation of thermal control unit

By closing contact switch 236 at the analyzer cam set 151, the automatic thermal control unit comes into operation for controlling the temperature of the inflowing water in accordance with the setting of the thermostat 124. This is accomplished by current flowing through contact 236, line 261, manual switch 262, line 263, terminal 264 of the terminal bar 249, and thence into

line 265 and the thermostatic switch 124. The other side of the thermostatic switch is connected through line 266 to the relay coil 267 which in turn is connected to the current line 202. As previously shown, line 202 is in turn connected to the other current line 205.

The purpose of energizing the relay coil 267 is to control the solenoid-operated valves 122 and 123, respectively, which in turn control the fluid pressure to the cylinder 116 for operating the dumb-bell piston 117 of the automatic thermal control unit (see Fig. 1B). In the position shown in the drawings, the solenoid on the valve 123 is energized by current passing through the main current line 206, switch 204, line 270, terminal 271 of the terminal bar, line 203, switch element 272 of the relay 267, and line 273. The other side of the solenoid of valve 123 is connected through line 274 and switch element 275 of the relay to the other current line 202. Similarly, the solenoid of valve 122 is connected through lines 276 and 277, respectively, to the switch terminals 278 and 279, respectively.

It will thus be seen that when the switch elements 272—275 are in the position shown in the drawing, the solenoid of valve 123 is energized, whereas when the switch elements 272—275 are moved into engagement with contacts 278 and 279, the solenoid of valve 122 is energized. It is further apparent that when one of the solenoids is energized the other is disconnected.

It should be understood that this automatic thermal control mechanism is put in operation as described at the same instant that the water starts to flow into the washing machine. Initially, the control piston 117, which acts to regulate the relative flow of hot and cold water, is in the position shown in Fig. 1B, so that cold water first enters the inlet pipe. However, at the same instant the relay 267 is energized so that the relay switch 272—275 is moved and valve 122 is opened, with the result that the control piston 117 is immediately moved to admit hot water. It will be apparent that the action of the relay 267 is under the immediate and automatic control of thermostatic switch 124 so long as the automatic thermal control unit is in operation, with the result that the relay is free to constantly shift the switch elements 272—275 to cause hot and cold water to be supplied in the desired ratio. This action produces a very accurate control of the temperature of the water, so that, for instance, if water at 160° is desired and the thermostat is so set, water at this temperature will be supplied to the washing machine.

Operation of dump valve mechanism

Referring now once more to the connections made at the analyzer cam set, it will now be shown that the closing of contact switch 237 serves to close the dump valve. This is accomplished by current flowing through the contact switch 237, into line 280, switch 281, line 282, terminal 283 of the terminal bar and line 284 which connects by parallel connections with the two solenoids which control the fluid valves 76 and 83, respectively. As more clearly shown in Fig. 4, these valves control the fluid pressure for operating the dump valve. The other sides of the solenoids are in turn connected directly to line 202 which, as previously shown, connects with the other of the current lines.

Inasmuch as the dump valve is normally open and requires fluid pressure for the closing thereof, and the further fact that the inlet for the fluid

pressure medium is controlled by a normally closed valve, it is required that the solenoids be energized in order to close the dump valve.

Energizing lower diaphragm magnet

The closing of the contact switch 238 at the analyzer cam set 151 serves to energize the magnet 143 associated with the diaphragm which is employed in the operation of the single pole, double throw switch 251. This is accomplished by current passing through the switch 238 into line 285, through terminals 286 into line 287 which connects directly with the magnet 143, as shown in Fig. 1B. The other side of the magnet is connected to the other current line 202 through line 288.

Energizing upper diaphragm magnet

Similarly, the contact switch 239 of the analyzer cam set 151 serves to energize the magnet 290 which is associated with the upper diaphragm and is employed in the operation of the switch 291. This upper magnet is energized by current passing from contact switch 239, through line 292, terminal 293 and line 294 which connects directly with the magnet 290. The other side of the magnet is connected with the other current line 202 through line 295.

Starting the timer motor

The contact switch 240 of the analyzer cam set 151 causes the timer motor 181 of the timer unit 180 to start operating, whereby the timer cam set likewise rotates because it is driven directly by the motor. This is effected by means of the current passing through the contact switch 240 and through line 300 which connects directly with the timing motor 181. The other side of the timing motor is connected through line 301 to line 228 which in turn connects with the other power line 205.

It should be understood at this point, however, that the operation of the timing motor and the timing cam set as just described does not have an immediate effect upon the automatic control mechanism, and further that it will not have such effect until such later time as when other connections are subsequently made, as will be hereinafter described. Nevertheless, the timer motor and the timer cam unit are placed in operation at the outset so that they will be immediately effective at the time the subsequent connections referred to are completed.

Operation of alkali feeding mechanism

Furthermore, the movement of the analyzer cam set also closes contact switch 241, which causes the valve 101, which controls the flow of alkali into the washing machine, to be opened. This operation is accomplished by current passing through contact switch 241, line 302, terminals 303 and line 304 which connects directly by parallel connections with the upper and lower solenoids associated with valves 101 and 110, respectively. The other sides of the solenoids are connected by parallel connections through line 305 with the line 202, and thus with the other current line. In consequence, along with the introduction of the water and the other operations above described, valve 101 is opened and valve 110 is closed, whereby the contents of the alkali tank 106 is caused to flow into the washing machine. The alkali tank may be vented by any suitable means, such as by a valve or by an up-standing pipe 319, as shown in Fig. 1B.

First circuit for analyzer solenoid

Contact switch 242 of the analyzer cam unit is a part of a circuit which includes the switch element 307 of the multiple switch relay 306 (shown at the lower right of Fig. 1A), the timer cam unit 180, and the solenoid 226 which operates the analyzer cam set when the circuit is closed. This circuit, however, remains open until the upper diaphragm switch 291 is opened, as will hereinafter be described. This circuit is as follows: Contact switch 242 connects through line 310 with line 311, the latter of which connects directly with the switch element 307 of the multiple switch relay 306. The other side of the switch element 307 connects through line 312 with line 313 and line 314 with the contact switch 246 which is one of the contact switches of the analyzer cam set. As shown, however, in Fig. 14, the contact switch 246 is also closed when the analyzer cam set is moved into the position of segment 232, whereby a connection is established through line 315 to the timing switch 316 of the timing cam set 180. The other side of the timing switch 316 is connected through line 317 to the analyzer solenoid 226 as shown in Fig. 1, and the other side of the analyzer solenoid 226 is connected through line 227 to the other of the current lines 205.

As previously explained, current can only flow through the circuit just described when the switch element 307 is closed, which is not the case when this circuit is set up by closing the analyzer contact switches 242 and 246. This is due to the fact that the coil 318 of the multiple switch relay 306 is immediately energized, when the washing machine is started, as will be later explained, whereby all of the relay switch elements associated therewith, including switch element 307, are at once moved to the dotted-line positions, or, in other words, to the positions in which the above-described circuit is broken. Hence, no current is passed to the analyzer solenoid 226 when the analyzer is first moved to the position represented by segment 232, as the closing of this circuit depends upon deenergizing the coil 318 of the multiple switch relay 306 so as to permit the multiple switch element, including the switch element 307, to be restored by spring action to the full-line position as shown in Fig. 1A. This action in turn depends upon breaking contacts 291 of the upper diaphragm switch, which does occur, as will be later described, when the suds level in the washing machine has reached a height sufficient to exert an internal pressure on the diaphragm associated with the upper switch 291. It will be seen, therefore, that when the diaphragm switch 291 is operated the relay 318 will be deenergized, and hence the circuit above described will be completed, whereby the analyzer cam set will be started in operation under the timed influence of the timer, at the moment the suds level reaches the desired height.

In considering this aspect of the analyzer cam set, an inspection of Fig. 14 will show that the actions of the cams 242 and 246 are identical.

In order to fully understand the operation of the multiple relay 306, shown at the lower right-hand corner of Fig. 1A, it should be observed that relay coil 318 has one side connected through line 126 with line 127 which extends up to and connects with line 334 which, as previously described, connects with one of the current lines. The other side of the coil, on the other hand, connects with line 128 which extends through the

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terminal 129 to the line 146 which connects directly with the lower contact of the switch 291 associated with the upper diaphragm. The other contact of this switch connects with line 147 which returns to the terminal bar at 148 and connects to line 270 which, as previously described, is the other of the current lines.

It will thus be seen that the relay coil 318 of the relay 306 is connected in a separate and independent circuit across the current lines and includes therein the switch 291 associated with the upper diaphragm. It will further be noted that when the contacts of the upper diaphragm switch 291 are engaged, a circuit is established which energizes the relay coil 318 whereby during the period that the coil is so energized all of the relay switches of the relay 306 are in the dotted-line position shown in Fig. 1A. Inasmuch as this is an independent circuit, the relay coil 318 will be so energized whenever the machine is in operation, and at the same time the upper switch 291 is in closed position. Consequently, during the interval of time commencing with the starting of the apparatus and terminating with the breaking of the switch 291 associated with the upper diaphragm, the switch elements of relay 306 are necessarily in the dotted-line positions as shown in Fig. 1A.

Initial soap feed

The contact switch 243 of the analyzer cam set is connected in the circuit which controls the soap inlet valve 105. However, there is also connected in this circuit a relay switch 320 shown in the lower right-hand corner of Fig. 1A. The coil 321 of this relay is energized from the same line which controls the solenoid-operated valves 76 and 83, which in turn operate the water inlet valve 90. In other words, the relay coil 321 is energized so long as water is flowing into the washing machine.

The circuit which controls the soap feeding valve is as follows. The current passes from the contact switch 243 through line 323 which connects with the switch element 324 of the relay 320. This switch element, when moved to the dotted-line position, connects with contact 325 and line 326, which in turn connects with line 327. Line 327 passes through terminal 328 which connects with line 329 which extends directly to the solenoid which controls the valve 105 in the soap supply line 44. The opposite side of the solenoid is connected by line 330 with line 202 which, as previously described, connects with the other current line 205.

For a complete understanding of the operation of this circuit, it should be further known that the relay coil 321 connects through line 331 with line 332 which in turn connects with terminal 254 and line 255. The other side of the coil 321 connects through line 333 with line 334 which connects with the current line 205. It has already been shown that the terminal 254 and line 255 are parts of the circuit which control the opening and closing of the water inlet valve 90, and hence it will be seen that the lines just described serve to connect the relay coil 321 in parallel with the water controlling circuit, whereby the relay is subject to the same timed operation.

Consequently, when the water is flowing into the washing machine, the soap control circuit above described, which has been connected by the analyzer switch 243, is closed by the relay switch 324 so that the soap flows coextensively with the introduction of the water. It will be

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apparent, however, that the above-described mechanism will likewise cause the above-described circuit to close the soap feeding valve when the flow of water is discontinued. It should be understood, however, that whereas it is not desired to stop the feeding of soap at such time, another circuit for maintaining the soap valve open for a further period is established automatically prior to the time that the above-described circuit is broken.

Additional soap feed

This brings us to the analyzer contact switch 244, which is a double contact type of switch. For purposes of clarity, the soap feeding action which takes place during the introduction of the water has been referred to as the initial soap feed, whereas the soap feeding action now to be described will hereinafter be referred to as the "additional soap feed."

Inasmuch as the additional soap feed starts when the water valve is closed, the automatic control now to be described utilizes in part the water control circuit. As previously described, the contact switch 235 of the analyzer cam set has been closed and was employed to open the water inlet valve. The circuit included lines 247, terminal 248 and line 250 up to the lower single pole, double throw diaphragm switch 251. This contact switch 235 is employed to send current up to the movable contacts of the diaphragm switch 251. This power which was used for operating the water valve is now utilized for the additional soap feeding circuit. The same movement of switch 251 under the influence of the diaphragm which breaks contacts 252, makes connection between the contacts 335. Thus, line 250 is disconnected from line 253 and at the same time connected with line 336. Line 336 connects through terminal 337 with line 338 which in turn connects with line 339 through the contact switch 244 of the analyzer cam set. Line 339 connects with line 340 which in turn connects with the switch element 341 of the multiple switch relay 306. Switch element 341, when moved to the dotted-line position under the influence of the relay coil 318, connects with contact 342 which in turn connects with line 343. Line 343 connects with line 327, previously described, at point 344.

As already described, the switch element 341 will be in dotted-line position under the influence of the relay coil 318 so long as the upper diaphragm switch 291 remains in contact, or, in other words, until the upper diaphragm switch is opened by means of the suds reaching a sufficient height to operate the upper diaphragm. It will thus be seen that the additional soap circuit just described will, therefore, serve to maintain the soap valve open after the water has been shut off and until the desired suds level is reached as determined by the level of the upper valve operating diaphragm.

Selector solenoid circuit

The contact switch 245 serves as one connection in the circuit which connects the solenoid 350 of the selector cam set 150 with the timer so that the selector will be driven in timed relation by the timer. In this form of the invention, the selector does not start to operate until the water has been shut off or, as previously pointed out, until the circuit controlling the initial soap feed has been broken by the relay 320 which is connected for control with the water feeding circuit. Consequently, use is here made of a part of the circuit which was utilized for the initial soap

feed to connect the selector solenoid 350 for operation by the timer cam set 180.

As already described, contact switch 243 of the analyzer cam set is closed when the analyzer is initially moved to the first segment 232, whereupon a connection is established from the contact switch 243 through line 323 with switch element 324 of the relay 320. As previously described, when the flow of water into the washing machine ceases, the controls which shut off the water valve act to deenergize the coil 321 of the relay 320. This causes the switch element 324 to assume the full-line position as shown in Fig. 1A, and to thereby connect line 323 with line 351 which in turn connects with switch element 352 of the multiple switch relay 306.

As previously described, when the upper diaphragm is down the relay coil 318 of the multiple relay switch 306 is energized, whereby the switch element 352 will be in dotted-line position, so that line 351 is connected with line 353 which in turn connects with line 354 which extends back toward the analyzer cam set and connects with line 355 through the contact switch 245 of the analyzer cam set. Line 355 in turn extends to and connects with the timer switch 356 which in turn connects with line 357. Line 357 connects with an electromechanical locking relay with manual reset 358, the purpose and function of which will hereinafter be more fully described. It may be mentioned, however, that this switch is shown in Fig. 11 as mounted on the control panel and having a manually operable lever 359. The other side of the electro-mechanical locking relay is connected to a line 360 which connects through the selector switch 216, previously described, with line 361 which is connected to the solenoid 350 associated with the selector cam set. The other side of the solenoid 350 is connected through line 362 with the other current line 205. It will thus be seen that the contact switch 245 of the analyzer cam set serves to connect the selector solenoid 350 for operation by the timer switch 356 during the period after the water has been shut off and prior to the time that soap feed valve is shut off.

Initial action produced by analyzer cam set

As has been pointed out, the analyzer cam set is initially moved from the position of segment 231 to the position of segment 232 by the initial manual movement of the selector cam set 150. It is to be understood that the action which results is entirely electrical and therefore substantially instantaneous, and consequently all of the above-described operations, except those which depend upon the existence of water or soap levels, occur immediately following the initial movement of the selector to starting position.

Insofar as the action on the washing machine is concerned, the movement of the selector to starting position causes the following events to occur, namely—

- (1) The washing machine motor to start operating;
- (2) The dump valve to close;
- (3) The water inlet valve to open;
- (4) The automatic temperature control unit to be connected;
- (5) The soap feed valve (under the control of the initial soap feed circuit) to be opened; and
- (6) The desired quantity of alkali to be introduced.

The additional connections which are made are all concerned with the establishment of additional circuits for the control mechanism rather than

the immediate occurrence of events at the washing machine.

With the apparatus thus started, water at the desired temperature flows into the washing machine, the alkali is introduced and soap is also being fed in at a predetermined rate. When the water has reached the desired level, as determined by the level of the lower diaphragm, the single pole, double throw switch 251 is moved as above described, so as to break the contacts 252 and establish contact 335. As previously indicated this shuts off the water, breaks the circuit for the initial soap feed, establishes the circuit for the additional soap feed, and starts the movement of the selector under the influence of the timer. During the subsequent period the soap continues to feed into the washing machine, and the selector is moved by the timer at a predetermined rate of speed. The soap feed is continued until the suds produced thereby reach a level determined by the position of the upper diaphragm. When the suds reach this predetermined level the diaphragm is lifted and contacts 291 are broken. The breaking of this circuit causes the soap valve to be closed and the movement of the selector to be stopped, and starts the movement of the analyzer cam set under the influence of the timer.

First suds operation

In the above-described manner, the first suds operation is started. As above pointed out, the analyzer cam set 151 is put in rotation by the timer 180 and the solenoid 226. As shown in Fig. 11, the solenoid 226 has a core 401 which operates the crank arm 403 through the connection 402. The return movement of the crank arm is caused by the spring 404 and is arrested by an adjustable stop 405. The crank arm carries the pawl 406 which is pressed by the spring 407 in engagement with the ratchet 408. Reverse movement of the ratchet is prevented by the spring pressed locking pawl 409. It is to be understood that the ratchet is mounted on a shaft similar to the shaft 160 shown in Fig. 9 on which are mounted the plurality of cam discs having peripheral shapes, respectively, as diagrammatically represented in Fig. 14.

The timing of the solenoid impulses can be adjusted in any manner desired, and likewise the ratchet 408 can be provided with any desired number of teeth. However, in this illustration the ratchet is provided with twenty-four teeth, and the solenoid is given that movement which moves the ratchet one tooth every twenty seconds. As a result, the analyzer cam set is moved 15 degrees for each movement of the solenoid, or, in other words, for each tooth movement.

As the analyzer cam set continues to move under the influence of the timer, the cam set moves progressively and with a step-by-step movement through the various segments represented on Fig. 14, and it will be noted that during the movement thereof the switch contacts 237, 239, 242 and 246 are maintained closed throughout approximately 285 degrees of movement thereof from zero position, and that the switch contacts 240 are maintained closed throughout approximately 345 degrees of movement of the cam set. In consequence, the first suds operation continues under the timed control of the analyzer throughout the first 285 degrees of movement thereof, or, in other words, approximately 6 minutes after all of the soap is introduced.

Dumping first suds

At this point, however, the contact switch 237 is broken, which controls the dump valve circuit, and hence at this point the dump valve again moves to open position.

In addition, contact 239 is broken, whereupon the circuit which energized the upper diaphragm magnet is also broken, with the result that the magnet 290 is deenergized. Similarly, switch contacts 242 and 246 are broken, whereupon the analyzer solenoid circuit which was under the influence of the suds level diaphragm-operated switch 291, is likewise broken. As previously shown, the maintenance of this last-named circuit depended upon the contact being established at both of the contact switches 242 and 246.

Direct circuit for analyzer cam set solenoid

In this connection, however, it should be observed that just prior to the breaking of the contacts 242 and 246, contact switch 410 is closed and that this new circuit serves to maintain the analyzer solenoid in operation for a longer period, notwithstanding the fact that contact switches 242 and 246 are broken.

This new circuit may be traced on Fig. 1 as follows: The line 220 which extends from the current line 206 passes through the switch 410 just referred to, and therebeyond through the line 411 to make direct connection with the line 315. As already shown, the line 315 extends to contact switch 316 of the timer, which in turn connects with the line 317 to the analyzer solenoid 226. As the other side of the solenoid is connected through the line 227 to the other current line 205, it will be apparent that the solenoid remains in operation under the influence of the timer, notwithstanding the fact that contact switches 242 and 246 are broken. As shown in Fig. 14, this new circuit created by the contact switch 410 continues for the next four movements of the analyzer cam set, or until this cam set has rotated a total of approximately 345 degrees from zero position.

Initial movement of selected formula cam set

After the analyzer cam set has moved approximately 300 degrees, the contact switch 415 is closed and remains closed for two tooth movements, or, in other words, for approximately 40 seconds. As shown on Fig. 1, the closing of this contact 415 serves to temporarily connect the operating solenoid of the particular formula cam set which has been designated by the selector 150. This temporary connection exists only for a period sufficient to cause the selected formula cam set to be moved one segment, or one tooth space of its ratchet. The purpose of this movement is to establish a new set of connections by means of the switches associated with the formula cam set so that the automatic operation may be continued under the controlled influence of the selected formula cam set after the initial suds operation has been completed under the control of the analyzer.

The circuit for accomplishing this result is as follows: The current from the line 206 passes through the line 220 into the bus-bar 221 through the contact switch 415 just described. From the control switch 415 the current passes through the line 416 into the line 417, and then to one of the selector switches A, B, C or D.

At this point it should be understood that the selector 150 has four switches A, B, C and D, only one of which can be connected at any one time. This will be more fully described hereinafter, and

will appear from an inspection of Fig. 13. For the purpose of describing this circuit, however, it will be assumed that the selector has stopped with the selector switch A in contact. The selector switch A connects through line 418 with the timer switch AT, which in turn connects through the line 419 with the solenoid 420 of the cam set 152 designated "A Formula" on the drawings. The other side of the solenoid 420 connects through the line 421 with the other current line 205.

A more complete understanding of this circuit may be had after referring to Fig. 13, where the cam shapes for the four selector switches A, B, C and D, respectively, are illustrated, and from which it will be seen that contact A is broken before contact B can be made, and in turn contact B is broken before contact C can be made, and, finally, that contact C is broken before contact D can be made.

Selector action in selecting particular formula

As previously described, the selector runs only during the period hereinabove referred to as "additional soap feeding" period, and inasmuch as the soap is fed in at a uniform rate of speed, the amount of soap required is proportional to the time involved in its introduction. Hence, the selector is advanced a definite amount in proportion to the period of the additional soap feeding action. Inasmuch as the amount of additional soap is in turn proportioned to the amount of soil present in the clothes to be washed, the selector here referred to automatically selects one of the formulas A, B, C or D, according to the requirements of the particular case or, in other words, according to the soap initially introduced as necessary for removing the quantity of soil present in the particular batch of clothes being treated.

Timer cam set

Reference should also be made to Fig. 12, which shows the set of six timer cams. The outer cam, designated 316, acts to drive the analyzer solenoid 226. Cams AT, BT, CT and DT are the timing cams for the solenoids, respectively, of each of the formula cam sets A, B, C and D. The innermost cam 356 is the timer cam for moving the selector. Inasmuch as the timer cam set is driven by a motor which operates at a uniform rate of speed, the timing of the various cam sets will be apparent from an inspection of the diagrammatic representation in Fig. 12. From this, it will be noted that if the analyzer is moved one tooth every 20 seconds, the formula cam sets are moved one tooth every 40 seconds. In other words, the cam notches such as 470 of the analyzer cam set are twice as far apart as are the notches on cam set 316. It is on this account that the contact 415 of the analyzer cam set remains closed for two tooth movements as illustrated in Fig. 14, because this assures that one moving impulse, and only one, will be given to the ratchet of the selected formula cam set. In other words, the contact switch 415 at the analyzer is maintained closed for 40 seconds, which is bound to overlap one of the contact intervals during which the formula cam solenoid is energized. On the other hand, it is not sufficiently prolonged to cause the interval when the contact switch 415 is closed to overlap two of such impulses, such as would cause the formula cam to go beyond the desired one tooth movement required therefor.

Final action of analyzer cam set

After the analyzer cam set has moved a total

of approximately 345 degrees, the contact switches 240 and 410 are broken (see Fig. 14). These contacts control, respectively, the timing motor circuit and the circuit energizing the analyzer solenoid through the timer cam set 180. It thus occurs that the analyzer cam set is brought to rest on the last segment 231, at which point contact 222 is re-established and, in addition, contacts 415, 430, AA, BB, CC and DD are made.

The purpose of contact 222 has been previously described as that of providing a connection by which the analyzer may be moved to its first position when the selector is moved manually, as when starting a washing operation. Thus, the contact 222 will serve in the subsequent washing operations as heretofore described.

Contact 415 once more connects the solenoid 420 of the selected formula cam set, such as, for example, formula A, with the timer, whereby the formula cam set may now take up the operation. However, it should be pointed out that inasmuch as the timer motor has been stopped, the circuit established by contact 415 will not immediately cause movement of the connected formula cam set. As later shown, this will depend upon the starting of the timer motor, which in turn will depend upon the suds level reaching the desired height.

New timing motor circuit

Contact 430 is likewise made to connect the timing motor in a new circuit which includes the suds level diaphragm switch 291. This new circuit is as follows: Line 228, shown at the lower left-hand side of Fig. 1, extends from current line 205 and connects with line 301 which is connected to the timing motor 181. The other side of the timing motor connects through line 300 to line 432 which connects through the contact switch 430 just described with line 433. It will be recognized that this line is a continuation of the previously described line 313. Line 313 connects through line 434, through the formula cam set contact switch 435 with the bus-bar 436. This bus-bar in turn connects through switch AA of the analyzer cam set which connects through line 437 with line 418, which extends between switch AT of the timer and switch A of the selector. The current then passes to the right, as shown in Fig. 1, through contact switch A of the selector, into line 416, and through contact switch 415 of the analyzer cam set into the bus-bar 221 and through line 220 to the line 206. This constitutes a circuit by which the timing motor may be run directly under the influence of the switch 435 of the formula cam set A, or, for that matter, any of the equivalent contact switches of the other formula cam sets B, C or D, respectively. However, it will be noted from Fig. 15 that at this point in the operation the selected formula cam set is at rest on segment 440, and that in such position the contact switch 435 is broken, and hence the timing motor is not yet started by means of this circuit. The purpose and value of this circuit will be later explained.

Operations controlled by selected formula cam set

The following description is that of the operation as provided by the selected formula cam set A, and may be taken as representative of various different possible formula cam sets which could be employed if desired, including such formula cam sets as B, C and D.

It is apparent that within the discretion of the manufacturer, various types of cams may be

employed providing for a greater or lesser number of suds and rinsing operations, respectively, and for effecting various combined operations of the particular circuits which have already been described. Accordingly, for the purposes of this disclosure only one formula cam will be described in detail, it being pointed out, however, that the various sets of switches of the respective formula cam sets may be connected in parallel whereby the particular connections made as hereinafter described can be made by any one of the particular formula cam sets according to its cam formations and provided the selector is properly positioned. As already pointed out, the selector will connect one, and only one, of the formula cam sets for operation to the exclusion of the others, whereupon the automatic operations which follow are controlled by the connected formula cam set irrespective of which of them may have been so selected.

First action of the formula cam set

In the first position of the formula cam set A the following contacts are made, namely, 445, 446, 447, 448, 449, 450 and 451 (see Fig. 15). Before describing the action of each of these contacts, it should be observed that the bus-bar 436 associated with the formula cam set A connects through contact switch AA of the analyzer (which has been closed in the final position on the analyzer cam set), with lines 437 and 418. Inasmuch as line 418 connects through contact switch A of the selector 150 with the line 416, and line 416 connects through the analyzer switch 415 with the bus-bar 221, and line 220, it is apparent that the bus-bar of only the selected formula cam set is energized. It will also be clear that any contacts made by the formula cam between the bus-bar 436 associated therewith and the various operating circuits will be effective to produce the desired operation of the machine parts in the same manner as that effected by the corresponding contact switches of the analyzer cam set. Accordingly, the effect of the formula cam switches will only be traced in this description from the bus-bar 436 to the particular circuit shown in Figs. 1, 1A and 1B in those cases where the circuit in question has already been described in connection with the action of the analyzer cam set.

Water feed

Switch 445 serves to connect bus-bar 436 with the line 247 through line 455 which, as previously described, acts to turn on the water.

Thermal control

Contact switch 446 connects the bus-bar to lines 456 and 261, which acts to energize the automatic thermal control mechanism for the water.

Dump valve

Contact switch 447 connects the bus-bar with lines 457 and 280 to close the dump valve.

Diaphragm magnet

Contact switch 448 connects the bus-bar with line 458 and circuit line 285 to energize the lower diaphragm magnet, and contact switch 449 connects the bus-bar with line 459 and circuit 292 to energize the upper diaphragm magnet.

Conditioning timing motor circuit

Contact switch 450 connects the bus-bar with line 460 and circuit line 310 to condition the timing motor circuit for control by the suds level

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diaphragm switch 291 in exactly the same manner that the analyzer solenoid 226 was so conditioned and controlled. In this case, however, the line 310 which extends through line 311 to the relay switch 307 and back to line 313 through line 312 extends on to line 433 and switch 430 of the analyzer cam set. Switch 430 is closed when the analyzer cam set is positioned on the last segment 231, and hence the circuit continues back through line 432 to line 300 and thence through the timing motor 181 and line 301 to the other power line 205. Thus, when contact switch 450 is closed, the timing motor is under the direct control of suds level diaphragm switch 291, whereas when contact switch 435 is closed the suds level diaphragm switch is disconnected and the timing motor is energized directly so long as the contact switch 435 remains closed.

Conditioning soap feeding circuit

Contact switch 451 connects lines 461 and 462, respectively, which in turn connect with circuit lines 339 and 338, previously described, which control the additional soap feeding operation. In other words, switch 451 in the formula cam set acts in the same capacity as the contact switch 244 of the analyzer cam set.

Summary of starting action of formula cam set

With the contacts thus established, it will be apparent that the dump valve is closed and the water is fed in at the desired temperature under the control of thermostat 124. It is also apparent that the upper and lower diaphragm magnets have been energized. The operation thus established continues until the water level reaches a height sufficient to exert its influence on the lower diaphragm in the manner previously described, whereupon the single pole, double throw switch 251 is moved so as to make contact 335 and break contact 252.

Starting feed of soap

This action has the same result as previously described, namely, it establishes the so-called additional soap feeding operation and at the same time cuts off the flow of water.

It is to be noted in this connection that in those suds operations which are controlled by the formula cams such as here described, no initial soap feed is made. This is preferred for the reason that a substantial portion of the original soap introduced during the first analyzing suds operation remains in the batch of clothes, which makes it unnecessary to add soap other than that introduced by the additional soap feeding circuit. However, the soap is fed in during the additional soap feed through the action of the circuit closed by switch 451 and the change in position of the single pole, double throw switch 251, whereupon the soap continues to feed in until the suds reach the level of the upper diaphragm. At this point, the contact 291 of the upper diaphragm switch is broken, with the result that the soap is shut off and the timer motor is started. This action occurs in a manner similar to that previously described, namely, by deenergizing the relay coil 318 of the multiple relay switch 306 shown in the lower right corner of Fig. 1A.

Starting of timing motor

This causes a movement of the relay switch 307 to full-line position, which establishes the circuit between lines 311 and 312 and thereby causes the timing motor 181 to be energized

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through the circuit which has been conditioned by the formula cam switch 450 and the analyzer contact switch 430. This circuit is as follows: From bus-bar 436 which, as previously shown, is connected with current line 206, through contact switch 450 and line 460, through lines 310 and 311, relay switch 307, line 312, line 313, line 433, line 432, line 300, timer 181, line 301 and line 228 back to the other current line 205. Thus, the formula cam set A starts to move under the influence of the timer switch AT which is connected, as previously described, with the formula A solenoid 420.

Continued action of formula cam set

As more clearly shown in Fig. 15, contact switches 445, 446, 448 and 451 are broken when the formula cam set moves away from the original contact segment 440. On the other hand, contact switch 446, which maintains the dump valve closed, remains closed, and contact switch 449, which energizes the upper diaphragm magnet, also remains closed. Similarly, contact 450, which controls the timing motor circuit, remains closed so that the timing motor will continue to run for the desired period. The operation thus started, therefore, continues until the formula cam set has moved through approximately 60 degrees, at which time contact 435 is made, as clearly shown in Fig. 15.

Feeding bleach

It should be noted at this point that when the formula cam set A moves to the second segmental position 470, a new contact switch 471 is closed. This contact switch connects the bus-bar 436 through line 472 and through switch 473 to line 474 which acts to open the valve 104 containing a measured quantity of bleach. This valve is a normally closed valve operated by a solenoid, whereas the upper valve 113 is a normally open valve also operated by a solenoid connected in parallel with the first-mentioned solenoid. When the lower valve 104 is open the upper valve 113 is closed, and vice versa. These solenoids are in turn connected through line 475 with line 202 which, as previously described, ultimately connects with the other current line 205.

Direct timing motor circuit

As previously described, after the formula cam set has been moved approximately 60 degrees, contact switch 435 is made. This contact is made just prior to the time that the contact switch 450 is broken, as clearly shown in Fig. 15, or, in other words, in such manner that there will be an overlap between the actions of these circuits. As already shown, contact switch 435 serves to energize the timing motor directly without utilizing the circuit therefor which is subject to control by the suds level diaphragm switch 291. Consequently, the timing motor continues to run even though the contact switch 450 is broken.

Opening dump valve and deenergizing upper magnet

At the same moment contact switch 450 is broken contact switch 447 is also broken, and consequently at this point the dump valve is opened. Similarly, switch 449 is likewise broken and the upper diaphragm magnet is deenergized.

By virtue of the fact that the timing motor is now operated directly by the circuit controlled by switch 435, the timing motor continues to run, with the result that the washing machine is given

a one-tooth movement which determines the dumping period. In the present illustration this is 40 seconds. After this interval, however, contact switch 435, which establishes direct connection with the timing motor, is broken and the timing motor is once more connected with the circuit established through contact switch 450 which is at once closed. Here again, however, the timing motor does not at once start to operate because, as already described, the circuit including the switch 450 is under the control of the upper suds diaphragm switch 291.

Starting rinsing operation

However, as shown in Fig. 15, at this point in the operation the switches 445 and 446 are again closed, and hence water at the desired temperature is again introduced into the washing machine. Switch 447 is again closed and the dump valve is likewise closed. Switch 449 is also closed so that the upper diaphragm magnet is again energized. It should here be noted that the lower diaphragm magnet is not energized but, as will now be shown, this is not necessary.

This marks the place in the operation of this particular formula where the rinsing commences, and it is now desired to fill the washing machine with water to the level of the upper diaphragm which formerly controlled the suds level. It will further be noted that no soap is caused to be introduced from this point forward, insofar as this particular illustrative formula is concerned.

Upper diaphragm control of water circuit

In order to cause the water to reach the level of the upper diaphragm, an additional water feeding circuit is established which operates to energize the water valve mechanism from the moment the flow of water is to be started until the moment when the level thereof reaches the height of the upper diaphragm. As a matter of fact, this is accomplished in this illustration by the use of two parallel circuits operating simultaneously to energize the water valve from the time that it is turned on until the time when the water reaches the level of the lower diaphragm and thereafter by the use of only one of the two circuits established at the outset of the operation. The second of the two circuits will be referred to as the "auxiliary circuit."

The auxiliary circuit referred to is established by closing contact 480 associated with the formula A cam set. From an inspection of Figs. 1 and 15 it will be noted that with the cam set in the position represented by segment 481, contact switch 445 is closed and as a result current passes from the bus-bar 436 through line 455 into the water feed line 247. The closing of contact switch 480 of the formula A cam set causes the current to pass from line 247, just referred to, into line 482 through the contact switch 480 and into line 483.

As shown in Fig. 1A, line 483 connects with the terminal 484 which in turn connects with line 485 which serves to energize the diaphragm loading device 486 which is associated with the upper diaphragm as shown in Fig. 1B. The other side of the diaphragm loading device is connected through line 487 with the other current line 202. The purpose of this loading device is that of readjusting the action of the upper diaphragm so that it will properly respond to the fluid pressure of water. This is desirable in view of the fact that the upper diaphragm is normally adjusted to respond to the reduced fluid pressure

characteristic of that produced by the suds, and accurate action thereof requires some readjustment. As shown in Fig. 1A, line 483 also connects with line 488 which extends downwardly to the relay 306 and connects with one side of the relay switch 489.

As previously indicated, whenever the machine is running with inadequate water or soap as the case may be, the upper diaphragm switch 291 is closed and thus relay switch 489 will be in the dotted-line position shown in Fig. 1A. The other side of the relay switch 489 connects through line 490 with line 491 which extends up to and connects with line 332 located at the top central portion of Fig. 1A. This line, it will be recognized, connects adjacent the terminal bar with line 255 which in turn connects with line 257 which controls the water valve mechanism. Thus, an additional circuit is established whereby current is supplied from the top water valve line 247 through the contact switch 480 and thence through the relay switch 489 and finally on to the water valve control mechanism. This circuit, therefore, assures the feeding of water continuously until the water level has reached the height of the upper diaphragm. When the water level reaches the height of the upper diaphragm, contact switch 290 will be broken and relay coil 318 will be deenergized and, in consequence, the relay switch 489 will move to full-line position. It is apparent that this movement of the relay switch 489 will break the water feeding circuit thus described, and hence the water will be shut off. Incidentally, the prior interruption of the circuit controlled by the switch 251 associated with the lower diaphragm has not influenced the feeding of water for the reason that the auxiliary circuit above described is maintained throughout the entire period.

Starting timing motor

At the same time that the upper diaphragm switch 291 cuts off the flow of water, relay switch 307 of relay 306 is moved from the dotted-line position to the full-line position, whereby the timing motor circuit, previously described, is closed. This is made possible through the fact that contact switch 450 of the formula A cam set has been closed in exactly the same manner that it was closed in connection with the commencement of the suds operation at the beginning of the formula A control action. Thus, the timing motor starts and the formula A cam set is advanced in the usual manner until after the cam set has moved a total of approximately 112½ degrees from zero position. At this point, contact switch 435 is closed, which serves to establish the direct timer motor circuit in the same manner previously described.

Dumping rinse

After the formula A cam set has moved a total of 120 degrees, contact switches 447, 449 and 450 are broken, whereby the timing motor is stopped and the dump valve is opened. The timing motor continues to operate, however, and thus times the dumping period which in this case is one tooth space or approximately 40 seconds.

Further rinsing operations

Thereafter, the formula A cam set is moved to the position of segment 492, where the same contact switches are closed that were closed in connection with the commencement of the previous

rinsing operation. In consequence, a duplicate rinsing operation is automatically effected.

In addition, as will be shown in Fig. 15, a similar third rinsing operation is also carried out, which finally brings the formula A cam set to a blue treatment operation which commences at segment 493.

Blue treatment

This operation is in many respects similar to the previously described rinsing operations, with the exception, however, that the thermal control switch 446 remains open, with the result that the bluing treatment is carried out with cold water instead of hot water. In addition, the contact switch 494 is closed after the water has been shut off, which serves to discharge the desired quantity of blue into the washing machine.

The circuit for discharging the blue is as follows: Current passes from the bus-bar 436 through the contact switch 494 and into line 495. This line connects with switch 496 which in turn connects with line 497. Line 497 passes through terminal 498 and connects with line 499 which is connected directly with each of the solenoids, respectively, associated with the control valves 103 and 112 of the blue measuring tank 108. The other sides of the solenoids referred to are connected through line 975 to the other current line 202.

In consequence, when contact switch 494 is closed the measured quantity of blue contained in the tank 108 is discharged into the washing machine. After the contact 494 is broken, the valves 103 and 112 of the blue tank are permitted to assume their normal positions, whereby the lower valve is closed and the upper valve is opened so as to recharge the blue tank with a fresh supply of blue. The bluing treatment is continued under the controlled influence of the timer until the formula A cam has traveled approximately 285 degrees, at which time the dump valve is opened and the timing motor circuit, which includes the upper diaphragm switch 291, is broken. Before this occurs, however, the timing motor is placed on the direct timing motor circuit controlled by contact switch 435, whereupon the timed movement of the formula A cam set is continued.

Sour treatment

This finally brings the formula A cam set to the position represented as segment 976, which marks the commencement of the final sour treatment. At this point, contact switch 445 is closed whereby the water is turned on, but contact switch 446 remains open so that the water will be cold and not hot. In addition, contact switches 447 and 448 are likewise closed. In consequence, the dump valve is closed and the magnet of the lower diaphragm mechanism is energized.

It should be pointed out here that whereas the rinsing and bluing operations are carried out with a larger quantity of water, namely, water introduced to the level of the upper diaphragm, this final sour operation is preferably conducted with a smaller amount of water which is shut off at the level of the lower diaphragm. This serves to give the desired concentration of sour without requiring an excessive amount of souring agent. In consequence, it will be noted that in the sour treatment contact switch 480, which establishes the auxiliary water feeding circuit, remains open.

Timing motor circuit under control of lower diaphragm switch

In addition, a connection is made by closing contact 977 for the starting of the timing motor when the lower diaphragm switch operates to turn off the water. It will be noted that this is the first occasion in the entire operation where the starting of the timing motor has occurred at the moment that the lower diaphragm switch is operated. During the suds treatments the timer motor was started when the upper diaphragm was actuated in response to the suds level, and during the rinsing and bluing operations the timing motor was also started by the upper diaphragm switch, though in response to the water level reaching the height thereof. During the sour treatment, however, contact switch 977, shown in Figs. 1 and 15, is closed, which serves to condition a new timer motor circuit which will be completed when the water is shut off.

To understand this circuit it should be remembered that when contact switch 445 is closed for operating the water valve, current is passed to the middle line 250 of the single pole, double throw switch 251 associated with the lower diaphragm, and that current passes through contact switch 252 when the water feeding circuit is energized. However, when the lower diaphragm switch is actuated by the water pressure, switch 252 is broken and contact is made at the opposite terminals 335. This causes current to pass from the center line 250 into line 336 which, when traced back toward the control mechanism, will be found to connect with line 338.

Just above the formula A mechanism as shown in Fig. 1, it will be noted that line 461, which connects with line 338, extends downwardly and makes connection with line 978 which extends over and connects with one of the terminals of contact switch 977. In consequence, when contact switch 977 is closed, current passes there-through and into line 979, and then into line 313. As previously described, line 313 constitutes a part of the timer motor circuit. The current from line 313 passes into line 433, through contact switch 430 of the analyzer cam set, into line 432, and finally into line 300 which extends to the timer motor 181. As a result, the closing of contact switch 977 conditions a circuit by which the timing motor may be operated when the water level single pole, double throw switch 251 is operated.

Introducing sour

When the timing motor is started, the formula A cam set moves to the next segmental position, at which time the contact switch 980 is closed. Contact switch 980 operates to discharge the sour in the same manner that the blue was discharged. The circuit for effecting this result causes current to pass from the bus-bar 436 through contact switch 980 and into line 981. This line connects with manually operable switch 982 and thence with line 983 which passes upwardly and through the terminal 984 of the terminal bar. This terminal bar connects with line 985 which extends up to and connects with the two solenoids, respectively, associated with the valves 102 and 111 of the sour measuring tank 107. The opposite sides of the solenoids referred to are connected through lines 986 with the other current line 202.

In consequence, when contact switch 980 is closed, a measured quantity of sour is dumped into the washing machine in a manner similar to that previously described in connection with the

blue. When contact switch 980 is again broken, the sour tank is again supplied with a measured quantity of sour for the next operation.

Direct timing motor circuit

It will also be noted that at the same time that sour is discharged, contact switch 435 is closed, which again establishes the direct timing motor circuit whereby the formula A cam set is moved on to time the souring operation.

Opening dump valve

As clearly represented on the cam chart of Fig. 15, when the formula A cam has moved a total of 345 degrees from zero position, contact switch 447 is broken, with the result that the dump valve is opened and the sour bath is discharged. The timing circuit, however, remains closed so as to ultimately move the formula A cam set to the final segmental position represented at 987. In this final position, contact 990 is closed. The purpose of this contact is to finally stop the operation of the machine.

Stopping machine

As shown in Fig. 1, when contact 990 is closed, current is free to pass from the bus-bar 436 through the contact 990 and into line 991. This line connects with line 992 whereby current passes to the left and thence downwardly to energize the solenoid 993 of the interlocked starting relay. This causes the switch points of the main current line to be moved to the dotted-line position so as to disconnect the entire apparatus.

It will be noted that the other side of the solenoid 993 is connected through line 228 to the other current line 205.

When the switch is moved to "off" position, a signal light 995, which is connected between the current lines, will come on to indicate the fact that the machine is at rest.

As previously pointed out, the interlocked relay employed for starting and stopping this control mechanism is of a type which requires that the opposite coil be energized in order to move the switch points. As already shown, the solenoid 217 of the interlocked relay is connected across the current lines but is under the direct control of the contact switch 215 of the selector, which switch must be closed by manual movement before the machine can be again operated. Inasmuch as the selector must be moved to starting position to move contact switch 215 thereof, it is apparent that the selector will always be restored to its original starting position before a subsequent operation can be carried out. It will also be apparent that the analyzer cam set and all of the formula cam sets which necessarily make complete revolutions in their operation will likewise be in the desired starting positions at the time each new operation is commenced.

In addition, if for any reason the starting switch 207 should be moved to "on" position without first moving the selector to starting position, the control device will, automatically, again move the starting switch 207 to "off" position because the formula cam set remains in position to close contact switch 990. Thus, the machine cannot be started except through the proper movement of the selector.

Various formula cam sets

In the foregoing description, only one formula cam set has been described although in the drawings four possible cam sets are illustrated. Attention is called to the fact that the C formula

cam set is shown by a fragmentary illustration, it being understood that it may be similar to formula cam sets A and B, respectively, with proper connections to the lines of the operating circuits, or it may be similar to formula cam set D. Furthermore, it is to be understood that any desired number of formula cam sets may be employed, it only being required that they be connected to the operating circuits and also connected for operation by the selector in the manner previously indicated.

Additional bleach and sour on formula cam set D

As best shown in Fig. 1A, additional and alternative operations may be provided on one or more of the formula cam sets, such as, for instance, causing more than one tank of bleach to be discharged into the washing machine, as, for instance, may be desired when extra heavy soil is being removed, and also causing alkali to be introduced in one or more of the suds operations after the first suds is carried out by the analyzer cam set.

For instance, additional bleach may be added by causing the bleach measuring tank to discharge initially in any particular operation when the water is introduced and thereafter to cause a second charge of bleach to be introduced in the manner previously described. In this way, two charges of bleach may be employed instead of one. This can be accomplished on formula D cam set by means of contact switch 1200 which serves to connect lines 1201 and 1202. Line 1201 connects directly with line 472 which is the main current line employed for controlling the discharge of the bleach tank. Line 1202 connects with manually operable switch 1203 and thence with line 1204. Line 1204 in turn connects with line 332 which connects with the terminal 254 of the water feeding circuit. It will thus be seen that when water is being fed at the same time that contact switch 1200 is closed, current which energizes the water valve will also flow into line 1204 through switch 1203 into line 1202 and thence through contact switch 1200 into line 1201, whereby the bleach feeding circuit will likewise be energized.

For the purpose of feeding additional alkali, a further contact switch 1205 can be employed, as shown on formula D cam set, which serves to connect the line 1206 with the line 1207. As line 1207 connects with the alkali feeding line 1202, it will be apparent that if contact switch 1205 is closed during that interval when water is being fed, current will pass from line 1202 into line 1206 and thence through contact 1205 into line 1207, so as to finally energize the alkali feeding mechanism. By providing a switch such as 1205, alkali can be fed in any of the subsequent suds operations, that is, those suds operations following the initial suds operation which is carried out under the control of the analyzer cam set.

Manual selection of desired formula cam set

In addition to the foregoing operation, it is possible by this mechanism to disconnect the automatic operation of the selector and to use any manually selected formula cam set which may be preferred. To accomplish this result, it is merely necessary to manually move the switch 358 shown in the lower left-hand corner of Fig. 1A. This, it will be noted, is connected in the circuit which operates the selector 150, whereupon the selector will not be operated in the usual manner during the interval between the time the water is shut off and the soap is subse-

quently shut off. Consequently, the selector will not be operative to automatically select a particular formula cam set, as would be the case if the control is on complete automatic operation.

It will be noted that switch 358 is under the control of the solenoid 1210 which, when energized, will restore the switch 358 to its original closed position. The solenoid 1210 is connected by lines 1211 and 1212, respectively, between the current line 205 and line 992, which, as previously described, is a part of the circuit which shuts off the entire apparatus at the end of the operation. It will be noted particularly that the solenoid 1210 restores the condition of the control mechanism for automatic operation so that on the next performance thereof the operation will be automatic unless switch 358 is again manually moved to the dotted-line or open position. When the selector is disconnected as indicated, the operator is free to pick any particular formula cam set he may desire by manually setting the selector to connect the particular formula cam set selected. These may be indicated on a dial on the front of the apparatus.

Operation by manual movement of switches

In addition to the foregoing, it is possible to operate this device by means of the manual switches 204, 1203, 281 and 262 shown on Fig. 1A and also on Fig. 11. In such an event, the automatic mechanism is entirely disconnected and the various valves and other control mechanisms are connected for electrical operation by the manual switches referred to. When this type of operation is desired, the main shut-off switch 210, shown in the upper left-hand corner of Fig. 1, is moved to the dotted-line position, in which event the current lines 208 and 209 are connected, respectively, to lines 1220 and 1221. It will be noted from Fig. 1A that line 1221 becomes a busbar for the four switches 204, 1203, 281 and 262, so that the movement of any one of these switches will energize its circuit to cause the operation of the connected mechanism. It will also be noted that switch 204 serves to establish a new set of connections for energizing the relay box 201 for starting the washing machine motor. For convenience in understanding the manual operation, switch 204 not only starts the motor but also connects the thermal control mechanism. In this type of operation, the bleach, sour and blue may be introduced by hand in the customary way.

Cut-out for bleach, sour and blue

It will further be noted from Figs. 1A and 11 that manual switches 473, 982 and 496 are provided in the bleach, sour and blue control circuits, respectively, whereby any one of these circuits can be cut out if desired at any particular time in the operation of this control mechanism. Each switch referred to has an associated switch arm which serves to connect a light across the current lines through connections 1230, as shown, so that these lights, respectively, will indicate when any one or more of the circuits referred to is cut out and thus is not operating.

SUMMARY OF OPERATION—FIRST FORM

A brief description of the operation of this first illustrated form will now be given. After the operator has placed the clothes or other articles to be washed or cleaned in the machine in the usual manner, the starting knob 212 of the selector cam set is moved manually to the position marked "Start." The first effect of moving the selector to "start" position is that the starting

switch is closed, and in consequence the motor for the washing machine starts to rotate the washing cylinder. In addition, this movement of the selector causes the analyzer cam set to be moved one segment and, in addition, certain other circuits to be conditioned for the operation hereinafter described.

By the movement of the analyzer to the first segment position, the various contacts thereon are closed, and, in consequence, the following events take place:

1. The dump valve is closed;
2. Water is fed into the washer;
3. The thermal control mechanism regulates the temperature of the water;
4. Soap is fed into the washer;
5. Alkali is fed into the washer;
6. The timer motor starts to operate;
7. The lower diaphragm mechanism is energized;
8. The upper diaphragm mechanism is energized;
9. An auxiliary soap feeding circuit is conditioned;
10. A circuit for the analyzer solenoid is conditioned; and
11. A circuit for the selector solenoid is conditioned.

Under the conditions just enumerated, water flows into the washing machine at the desired temperature and continues to flow until the water level in the machine is sufficient to actuate the lower level diaphragm mechanism which in turn throws a switch which causes the flow of water to stop. During the water feeding period, soap and alkali have been introduced into the washing machine. At the moment the lower diaphragm switch is operated to cut off the water, a circuit which feeds additional soap is established so that additional soap flows into the washing machine at a predetermined rate. This additional soap continues to flow until the level of the suds in the washing machine actuates the upper diaphragm mechanism and causes a circuit to be broken. Simultaneously with the feeding of the additional soap, the selector circuit was completed, with the result that the selector was being advanced at a uniform rate of speed during the additional soap feeding period. The moment the additional soap feed was discontinued, however, the selector also stopped and, in consequence, was brought to rest in a position to connect one of the formula cam sets, depending upon the period of time that the selector was so operating.

Furthermore, the operation of the higher diaphragm causes the circuit between the timer and the analyzer solenoid to be completed, with the result that the analyzer cam set is advanced by a step-by-step movement, and thus times the first suds operation. Before the analyzer cam set makes a complete revolution, however, a new circuit is established for rotating the analyzer cam set solenoid under the influence of the timer. When this new circuit is established, the original circuit, which includes the diaphragm-controlled switch, is disconnected.

The first suds operation is conducted during the period of a portion of the movement of the analyzer cam set, and when completed the dump valve is opened and the cleaning liquid discharged. The remaining period of operation of the analyzer cam set gives the washing machine a chance to empty, and when the analyzer cam set comes to its final position the control is immediately taken

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over by the selected formula cam set as will now be described.

After the analyzer cam set is moved a certain number of degrees, it occurs that the analyzer cam set moves to the position of the last segment, at which the driving circuit for the analyzer cam set is broken and the analyzer cam set is brought to rest.

During the movement of the analyzer cam set but after the selector had discontinued its operation, a contact was made which caused the particular formula cam set connected by the selector to be moved from its final position to the position of its first segment. This results in the selected formula cam set being in position to establish a series of contacts necessary to start the second suds operation.

By the initial movement of the selected formula cam, contacts are made which become active upon the analyzer cam set reaching its final and inactive position. As these contacts are closed, the following takes place:

1. The dump valve is closed;
2. Water is fed into the washer;
3. The thermal control mechanism regulates the temperature of the water.
4. The lower diaphragm mechanism is energized;
5. The upper diaphragm mechanism is energized;
6. A circuit for operating the timer motor is conditioned;
7. A circuit for feeding soap is conditioned; and
8. The previously established circuit for operating the timer motor is broken.

Under the conditions thus established, the water fed into the washing machine continues to flow until it is shut off by the operation of the lower diaphragm mechanism. The same action that shuts off the flow of water causes the soap to start to flow. During the water and soap feeding periods the timer is not operating. The soap continues to flow until the suds level causes an actuation of the upper diaphragm mechanism which, upon being actuated, causes the soap feed to shut off and the timing motor to start.

The cam may also provide for feeding bleach into the washer during the second suds operation. When the timing motor starts, the selected formula cam operates under the timed influence of the timer and progresses step-by-step until the suds operation has been conducted for the desired period, whereupon the dump valve is opened and the washing liquid discharged. Before completing the suds treatment, a new circuit for operating the formula cam solenoid from the timer is established and the original circuit, which included the upper diaphragm control, is disconnected. By virtue of the new circuit the formula cam continues its step-by-step rotation and all of the original contacts are re-established and an additional and similar suds operation, under the influence of this formula cam set, is carried out.

After the final suds called for by the particular formula cam set is complete, the dump valve opens and discharges the cleaning liquid. In addition, the upper diaphragm mechanism is closed.

After the last suds operation is completed, the selected formula cam set moves to a position to start the prescribed rinsing operations, in which position the following takes place:

1. The dump valve closes;
2. Water is fed into the washer;

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3. The thermal control mechanism regulates the temperature of the water;

4. The upper diaphragm mechanism is energized;

5. The timer motor circuit under the control of the upper diaphragm is conditioned;

6. The mechanism for controlling the flow of water is connected with the upper diaphragm mechanism and disconnected from the lower diaphragm mechanism; and

7. The drive circuit for the timer is discontinued.

With the conditions thus established, the water is fed into the washing machine until the level thereof reaches the height of the upper diaphragm. At this point the upper diaphragm mechanism is operated, the water is shut off, and the timer motor is started. This action constitutes a rinsing treatment, which is continued under the timed influence of the selected formula set.

After the rinsing has been conducted for the prescribed period, a direct timer circuit is established and the original timer circuit is broken. Thereafter, the dump valve is opened and the rinsing liquid discharged. According to the particular formula cam, the rinses can be hot or cold and, of course, any number of hot and cold rinses can be provided by varying the cam to provide therefor.

After the rinsing treatment just described, the operation is continued for a suitable blue treatment, with the result that the formula cam is brought to a new position which causes the following events to take place:

1. The dump valve is closed;
2. Water is fed to the washer;
3. The upper diaphragm mechanism is energized;
4. The timer circuit, including the diaphragm, is conditioned; and
5. The control of the water feed mechanism is disconnected from the lower diaphragm mechanism and connected to the upper diaphragm mechanism.

With the connections thus made, water feeds in until it is cut off by the upper diaphragm mechanism, which action also serves to start the timing motor. At a suitable time thereafter, blue is introduced. The rinse treatment is continued under the timed influence of the formula cam, the timer drive for which is next shifted from the diaphragm-controlled circuit to a more direct circuit.

Following this blue treatment, a treatment may be conducted under the timed influence of the cam formula which is similar but which differs therefrom in that sour is introduced instead of blue. In this instance it is found more economical to have the water feed connected for control by the lower diaphragm mechanism so that the large amount of water which would otherwise be introduced is not present to dilute the sour introduced.

After the sour is completely introduced, the direct timer circuit is again created and the original timer circuit under the influence of the diaphragm is broken. Thereupon, the dump valve is opened and the sour liquid discharged. In the final position of the formula cam a contact is made which causes the timer motor to stop altogether and a final contact is made for moving the starting relay switch to "off" position. Thereupon the washing machine stops rotating and the operation is completed.

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In addition to the foregoing, the operator may operate any of the mechanisms utilized in the cleaning treatment by manual control of the circuits without reliance upon the automatic control devices.

SECOND FORM

[Figures 16 to 23, inclusive]

GENERAL CHARACTERISTICS

The modification shown in Figs. 16 to 23, inclusive, is illustrative of another embodiment of this invention and is particularly characterized in that it provides for the desired number of suds operations according to the need therefor, as determined automatically by means of a photoelectric cell and thereafter, by a similar means, the desired number of rinses as may be required to substantially completely remove the soap from the washed clothes. This modification further provides for the automatic treatment of the clothes with bleach, blue and sour.

In addition to the foregoing, this form of the invention provides an alternative control by which a pre-set number of washes may be given, followed by a pre-set number of rinses. With either one or both of the pre-set operations this modification likewise provides for the introduction of bleach, blue and sour. Furthermore, this form of the invention provides suitable switches by which the automatic control may be entirely disconnected, with the result that the closing of the dump valve, the introduction of the water, and the connection of the automatic thermal control mechanism may be effected through manually operated electrical switches, each independently of the other.

A more complete understanding of this form of the invention, as well as its various modes of operation, will be had by consideration of the following detailed description thereof which will refer to the parts and connections found in Figs. 16 to 23, inclusive, of the accompanying drawings.

WASHING MACHINE CONSTRUCTION

Machine proper

The washing machine proper will not be described in detail because any suitable washing machine may be employed, and the type illustrated in Fig. 16B is substantially the same as that shown in Fig. 1B as described hereinabove. The actual parts of the washing machine itself will be identified on Fig. 16B by the same reference numbers used for the corresponding parts found on Fig. 1B. Furthermore, the dump valve mechanism and control therefor is similar to that previously described, as well as the various valves for the introduction of water, bleach, blue, sour and soap. In addition, the automatic thermal control mechanism is the same as that previously described and, accordingly, none of these parts will be described again.

Diaphragm mechanisms

It will be noted from Fig. 16B that three diaphragm-operated switches are employed in this form, instead of two as in the previous modification. The lower diaphragm-operated switch designated generally 500 and the intermediate diaphragm-operated switch designated generally 501 are somewhat similar to the lower and upper diaphragm switches previously described, except, however, that the intermediate diaphragm switch does not have a magnet associated therewith to quickly snap up and hold a magnetic plug on the diaphragm. On the contrary, the intermediate

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diaphragm may be operated entirely by the internal hydraulic pressure and consequently is free to disengage the switch when the internal pressure is reduced, as, for instance, when the suds level drops. Furthermore, there is a third diaphragm-operated switch located above switch 501 which is designated generally 502 and which, from the standpoint of construction, is substantially like the intermediate diaphragm-operated switch 501. The various controls effected by these diaphragm-operated switches will be described later.

It is to be understood that the particular diaphragm-operated mechanisms are not essential to this invention, as any other suitable liquid level operating switch mechanism may be employed in place thereof. For instance, good results have been obtained by employing low water cut-off contacts connected for operating relays in place of the diaphragm switches here illustrated.

Discharge ducts for photo-cells

Another difference in the construction of this machine resides in the provision for a bleeding or discharge pipe 503 which extends from the base of the washing machine and which is preferably equipped with a valve 504 which is capable of adjustment to permit the washing liquid to be discharged therethrough at the desired rate of flow. The bleed pipe 503 is equipped with two transparent or light-transmitting sections 505 and 506, respectively, whereby light may be transmitted therethrough and through the liquid passing through the pipe 503, all for a purpose hereinafter more fully described.

CONTROL MECHANISM

The control mechanism of this modification will now be described in detail. That portion of the control which provides for the automatic operation will be described first.

Current lines and starting switch

As shown in the upper left-hand corner of Fig. 16, lines 511 and 512 are the two current lines. These connect through a double throw switch 513 to current lines 514 and 515, respectively. Lines 514 and 515 connect through the double throw manual switch with magnetic reset 516 which connects the current lines with lines 517 and 518, respectively.

Driving motor circuit

By referring to Fig. 16A, it will be noted that line 518 connects through line 519 to the double throw switch 520, the other switch element of which is connected to line 517. In this manner, the current passes through lines 521 and 522, respectively, and terminals 523 and 524, and thence through lines 525 and 526 into the box 527 shown in Fig. 16A. This box diagrammatically represents an operating relay together with reversing mechanism for the washing machine motor, whereby current from the line 528 is connected to the washing machine motor 529 for the operation thereof. It is not essential that reversing mechanism be used, but it should be understood that the relay contained in box 527 will serve to connect the motor for either reversing mechanism, as is well known, or in a unidirectional manner, as may be desired.

Three cam sets

This control employs in addition to conventional and well known electrical switches and relays, three solenoid-operated cam sets which

are employed for making and breaking contact switches in connection with the control of the washing cycle. These are designated generally 540, 541 and 542, as shown in Figs. 16 and 16A. Structurally, these cam sets may be like those employed in connection with the previously described modification and as specifically illustrated in Figs. 9 and 10. In other words, each cam set may comprise a plurality of disc members, formed of insulating material, fixedly mounted on a rotatable shaft which is advanced by a solenoid-operated ratchet mechanism under the influence of a master timing device.

Timer

On Fig. 16, the timer is designated generally as 543 and is operated by a motor similar to the timer previously described.

Initial position of washer cam set

When the mechanism is at rest, as when a washing operation has been completed, the washing cam set is disposed with segment 544 in position to control the contact switches associated therewith. As more clearly shown in Fig. 18, it will thus be seen that at this point cam switches 545 and 546 are closed. The fact that contact switch 546 is closed at this point is relatively unimportant except for the fact that it acts to transfer the control from the washing cam set to the rinsing cam set as will be hereinafter more fully described, but it should be known that the current to the washing cam set is disconnected so long as contact switch 546 remains closed, or, in other words, so long as the washing cam set remains at rest in the position of segment 544.

Start of washing operation

In order to start the washing operation, the clothes are placed in the washing machine in the usual manner and the double throw manual switch with magnetic reset 516 is pulled out by the operator to move the switch elements to the full-line position, as shown in Fig. 16. This starts the motor of the washing machine in the manner above described, and also causes current to pass from line 518 into line 548 through switch element 549 of the double solenoid relay 550. From the switch element 549, current passes into line 551 and to one of the contacts of the switch 552 of the master timer 543.

Initial movement of washer cam set

As shown in Fig. 17, the timer contact switch 552 is represented as the outside ring and it should be understood that this switch might at this point in the operation be at rest in any circumferential position, that is to say, the timer is not designed to have a fixed stopping position. Accordingly, it might occur that the timer has stopped at a point where contact is made, and then again it may be stopped at a point where the contact switch 552 is broken. In the event the contact switch 552 of the timer is closed, the current will pass therethrough and into line 553 and into the solenoid 554 which controls the washer timer cam set. The other side of the solenoid 554 is connected through line 555 with the other current line 517.

It is apparent that this action will result in the washer cam set receiving one impulse of movement from its solenoid, whereupon the washer cam set will be moved from segment 544, as shown in Fig. 18, to segment 556. This is the desired movement incident to starting the machine in operation.

Initial starting of timing motor

If it should occur, however, that the contact switch 552 at the master timer is broken as above suggested, it will then be necessary to energize the timer motor for a sufficient period to cause the contact switch 552 to be moved to closed position. This is accomplished by current passing from the line 551 through contact switch 545 of the washer cam set (which is already closed) and into line 557 which extends to the switch element 558 of the double solenoid relay 550. This relay, being in the full-line position indicated in Fig. 16, causes the current to pass into lines 559 and 560 and down through line 561 into the timing motor 562. The other side of the timing motor is connected through lines 563 and 564 to the other current line 517. In this manner the timing motor is put in operation, whereupon the contact switch 552 of the master timer is within a few seconds brought to contact position, with the result that the solenoid 554 of the washer cam set is given an impulse through the above-described circuit. The result of this operation is that the washer cam set is moved from segment 544 to segment 556.

It should be noted at this point that this movement of the washer cam set causes the contact switch 545 to be broken, whereupon the above-described circuit, which was employed for energizing the timer motor, is likewise broken, with the result that the timer motor immediately stops running. This, of course, follows only in the event that the timing motor was put in operation in the first place. It is to be understood that the operation above described occurs almost instantly following the manual movement of the starting switch 516, or, at most, within a few seconds thereafter.

Washing cam set in starting position

We now find that the washing cam set occupies the position represented by segment 556, in which event contact switches 570 and 571 are closed. It may be of assistance to explain at the outset that the circuits established by these contacts 570 and 571 operate to close the dump valve, open the water valve, and connect the automatic thermal control mechanism. In addition, they close a switch in a circuit which will later be effective to feed soap or a soap-alkali mixture, or soap and alkali separately as may be desired, and also close a second switch which will later be effective to start the timing motor. However, the control circuits for soap and alkali will not become effective until the water is cut off, and the timing motor circuit will not become effective until the soap feed is discontinued.

Water feed

The supplying of water to the machine is accomplished as follows: Current passes from line 551 through circuit switch 570 into line 572 through the coil 573 of the multiple switch relay 574 into lines 575, 576 and 577 back to the other current line 517. This causes the three switch elements 578, 579 and 580 of the relay to be moved from their initial "off" positions to the full-line position shown in Fig. 16. The lower relay switch 578 serves to connect the control mechanism for the water valve, whereby the same is opened. The circuit for this purpose is established through lines 581, 582 and 583, which extend from the current line 551 to the switch

element 578 and serve to convey the current to line 584.

As more clearly shown in Figs. 16A and 16B, line 584 extends to the terminal 585 of the terminal bar 586 and then connects with line 587 which extends to the middle contact element 588 of the single pole, double throw switch 500 which is operated by the lower diaphragm associated with the washing machine.

When the diaphragm is in the lower position, the contact element 588 is in engagement with contact element 589 which in turn connects with line 590 which extends to the terminal 591 of the terminal bar and connects with line 592 which extends back through terminal 593 and line 594 and up to the solenoids which control the water inlet valve 595.

These solenoids are connected in parallel and their other terminals are connected through line 596 to line 597 which, as previously indicated, connects with the other current line 517 when the double throw switch 520 is in the position as shown in Fig. 16A, or, in other words, when the switch is adjusted for automatic operation.

It will be apparent that the establishment of this circuit operates to open the water valve, and at the same time the single pole, double throw switch 500 has been connected in the water valve circuit whereby the flow of water may be cut off by the switch 500 when it reaches the level of the lower diaphragm associated with the washing machine.

Thermal control circuit

The second relay switch 579 shown in Fig. 16 serves to connect the automatic thermal control mechanism whereby the water which is fed into the washing machine is automatically adjusted to the desired temperature. The control mechanism will not be described in detail as it is here represented as being of the same construction as that employed in connection with the other modification. The circuit, however, is as follows: One side of the relay switch 579 is connected to the line 583 in the manner previously described in connection with the water control relay switch 578. The other side of the switch connects through line 598 with manually operable switch 599 which in turn connects with line 600 which passes through the terminal element 601 into line 602 which passes up and connects with the thermostatic control 603 of the automatic thermal control device. The other side of the thermal control 603 connects through line 604 with the coil 605 of the multiple switch relay 606. The other side of the coil 605 connects through line 607 with lines 597 and thus with the other current line.

It will be apparent that the thermal control device is thus put in operation, whereby the multiple relay 606 responds to the temperature condition to feed hot and cold water in the desired proportions, all as previously described in connection with the other modification. It may be mentioned, however, that the solenoids for operating the valves are connected to one current line through line 608 and to the other current line through line 609.

It will thus be seen that the thermal control mechanism is placed in operation immediately when the water starts to flow into the washing machine, and that it remains in operation so long as the water is running. As will be observed from studying the wiring diagram, the thermal control unit will remain connected for a brief

period even after the water has been shut off, but this is not objectionable because it has no influence except when the water is flowing into the washing machine. The circuit which connects the automatic thermal control will, however, be broken when the switch 570 of the washer cam set is broken, or, in other words, when the washer cam set is moved to the next segment, as hereinafter described.

Conditioning initial soap feeding and additional circuits

The closing of the upper relay switch 580 of the multiple relay 574 serves to condition a circuit which will later be completed to open the soap feeding valve. This circuit also includes an open switch under the control of the lower diaphragm which actually completes the circuit, whereby the soap will start to flow at the time the water is shut off.

The circuit for this operation is as follows: As previously described, the closing of relay switch 578 has made line 587 a current line which constitutes a part of the water feeding circuit so long as contact element 588 of the single pole, double throw switch 500 is in engagement with contact element 589. However, when the diaphragm is lifted, as when the water has reached the desired predetermined level, the diaphragm acts to move contact member 588 into engagement with the upper contact member 610. Inasmuch as the soap is not fed until the water is discontinued, a part of the circuit which was utilized to control the water valve can now be used to control the soap valve to the extent indicated. It will thus be seen that current will flow from contact member 610 into line 611, through terminal 612 into line 613 which connects directly with the upper relay switch 580, the function of which is now being described.

The other side of this relay switch connects through line 614 with a switch element 615 of a second multiple relay 616 and thence through line 617, terminal element 618 and line 619 directly with the solenoid which controls the soap feeding valve 620. The other side of this solenoid connects through line 621 with the line 597 which, as already described, connects with the other current line.

It will thus be seen that the soap cannot be fed so long as the water is flowing into the washing machine, but that upon movement of the single pole, double throw switch 500 the water feeding circuit is broken and the soap feeding circuit is made, so that the soap valve 620 is immediately opened.

As previously shown, the soap feeding circuit included switch element 615 of the multiple relay 616 which will be employed in a manner hereinafter shown to discontinue the soap feed after the suds have reached a predetermined level or, in other words, the level of the diaphragm which controls the switch 501 shown in Fig. 16B.

Mixture of soap and alkali may be used

At this point it should be explained that the desired washing procedure also employs alkali in the washing liquid, which should be present in the desired quantity in conjunction with the soap at the time the suds level is utilized as indicative of the presence of the desired quantity of soap.

In certain instances, as when the soil is light, alkali may be employed of a type and in sufficient quantity which may be introduced in admixture with the soap, in which event no special mecha-

nism is required for such introduction because the soap feeding pipe may be connected to a mixture of soap and suitable alkali instead of to soap alone. In such case, the opening of the soap feed valve will supply both soap and alkali in admixture. However, in other instances where the soil may be heavier, it may be desirable to add alkali in addition to that admixed with the soap during the first suds operation. Such additional alkali is sometimes required for the subsequent suds operations.

Introduction of alkali

For this purpose an additional circuit has been provided which receives its current from the soap feeding circuit, whereby alkali may be fed during the feeding of the soap in connection with the first suds operation. This circuit will now be described.

As shown in Fig. 16, it will be noted that line 650 connects with the current line 649 and that its other end connects with the relay switch 651. This switch will be normally open, that is to say, in the dotted-line position, and will be closed only in the manner hereinafter described, when the soap feeding line is energized. The other side of relay switch 651 connects with line 652 which in turn connects with the switch element 665. The other side of switch 665 connects through line 666 with the switch element 653 of a manually operable, double throw switch shown in the lower right-hand corner of Fig. 16A. The purpose of switch 665 will be later described as that of providing a somewhat modified operation. The other side of the switch element 653 connects with line 654 which extends to the terminal element 655 and in turn to line 656. Line 656 connects with the solenoids, respectively, of the upper and lower valves 657 and 658 which are associated with the alkali measuring tank 659. The other sides of the solenoids are connected through line 660 with the other current line 597. As in the other modification, the lower valve 658 is normally closed, whereas the upper valve 657 is normally open, whereby the alkali tank normally holds a measured quantity of alkali. When the solenoids are energized, however, the upper valve is closed and the lower valve is opened, permitting the measured quantity of alkali to be introduced into the washing machine. As long as the solenoids remain energized, the upper valve will remain closed, whereupon no more alkali can pass into the measuring tank.

For the purpose of operating this circuit as above indicated, the switch element 651 is formed as a part of a double solenoid relay 661 which has an operating coil 662 and a reset coil 663. The operating coil 662 is connected through line 664 with line 617 which, as previously described, is the current line in the soap feeding circuit, and the other side of the operating coil 662 is connected through line 564 with the other current line 517.

The circuit for operating the reset solenoid 663 will be described later.

It should be understood at this point that the double solenoid relay 661, like the other double solenoids hereinafter described, are of the type in which the switch elements are moved in one direction by one solenoid and in the other direction by the second solenoid; or, in other words, are of the type in which the switch elements remain in their existing positions until they are positively moved by energizing the opposite solenoid.

From the foregoing description, it will be apparent that the switch element 651 of the double solenoid relay 661 is normally in open position, as shown in dotted lines in Fig. 16, and that the switch will not be moved to closed full-line position until the operating solenoid 662 is energized. However, as this coil 662 is connected through line 664 to the current line of the soap feeding circuit, it will be apparent that when switch 580 is closed by the action of the relay coil 573, the operating coil 662 will be energized and the relay switch 651 will be moved to closed position. In consequence, when the switch 665 is in full line position as shown in Fig. 16A, the alkali-feeding valves 657 and 658 are operated, and a measured quantity of additional alkali is introduced into the washing machine simultaneously with the opening of the soap feed valve.

If in any particular operation it should be desired to omit the feeding of the additional alkali, this can be readily accomplished by moving the double throw manually operable switch 653, shown in the right-hand corner of Fig. 16A, in which event the alkali feeding circuit referred to is deenergized. The other switch element of this double throw, manually operable switch 653 controls a light-indicating circuit which will later be described.

When the alkali feeding circuit is deenergized, the valve 658 at the base of the alkali container resumes its normally closed position, in which position it remains until the circuit referred to is again energized.

As previously explained, the resetting of the double solenoid relay 661 involves energizing resetting coil 663, and until this occurs the relay switch 651 will remain in the full-line position as shown, and consequently the alkali tank will not be refilled and hence will not discharge alkali during the subsequent suds operations.

In the event that the operator should desire to feed alkali separately from the soap during each suds operation, he may cause this to automatically occur by merely moving the switch 665 to the dotted-line position shown in Fig. 16A, in which event the lines 666 of the soap feeding circuit will be connected through line 667 directly with the current line 617 of the soap feeding circuit. At the same time, it will be apparent that the double solenoid relay 661 is entirely disconnected.

With this new circuit thus established by switch 665, the alkali feeding circuit is connected in parallel with the soap feeding circuit and consequently the alkali feeding valve will open and close at the same time that the soap feeding valve is opened and closed. As a result, a predetermined quantity of alkali is introduced into the washing machine during each suds operation initiated at the time the soap feed starts.

Washer contact switch 571

As previously indicated, when the washing cam set is in the position represented by segment 556 (see Fig. 18) contact switch 571 is also made which serves to close the dump valve and also condition a circuit for the timing motor so that the timing motor may be subsequently put in operation at the same time that the soap flow is discontinued.

The effect of closing contact switch 571 of the washer cam set is that of connecting the current line 551 through the contact switch 571 with line 622, which in turn connects with coil 623 of the multiple relay 624. The other side of the

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connects through line 625 with line 576 which, as previously described, connects with the other current line 517, through line 577. This energizes the relay coil and causes the switch elements 626 and 627 to be moved to the full-line position shown in Fig. 16.

Dump valve

The effect of closing switch 626 is that of energizing the control mechanism for closing the dump valve. The dump valve here employed is the same as that shown in connection with the other modification or, in other words, is a normally open valve which requires the constant application of current thereto to maintain the same in closed position.

The circuit by which the dump valve is closed is as follows: One side of the switch element 626 is connected through line 628 with the line 582 which, as previously described, is ultimately connected to current line 518. The other side of the relay 626 is connected through line 629 with the manual switch element 630 shown at the lower central portion of Fig. 16A. The other side of the switch 630 connects through line 631 with terminal 632 and thence with line 633 which extends directly to the solenoids for controlling the dump valve, here designated generally as 634. The other sides of the solenoids are connected, as shown in Fig. 16B, directly with line 597 which, as previously described, is connected to the other current line 517.

It will thus be apparent that so long as the relay switch 626 remains closed, the dump valve will in turn remain closed; and further, that the relay switch 626 will remain closed so long as the contact switch 571 of the washing cam set remains closed under the influence of its cam.

Conditioning timer motor circuit

The upper relay switch 627 serves to condition a circuit which will later be employed to start the operation of the timing motor when the flow of soap is cut off. This circuit, therefore, necessarily includes the contacts of switch 501 which is controlled by the middle diaphragm associated with the washing machine.

This circuit is as follows: One side of the switch element 627 is connected to the current line 518 through the lines 628 and 582, as previously described in connection with the dump valve switch 626. The other side of the relay switch 627 connects through line 635 with the switch element 636 of the multiple relay 616.

It will be noted that with the relay 616 in the position shown in Fig. 16, switch element 636 is open and, therefore, the connection is broken. However, it will further be noted that switch 636 will be moved to closed position at the same time that switch 615 is open, or, in other words, at the moment the soap feed is shut off. As will hereinafter be shown, this movement of the relay switches 615 and 636 will be caused by the soap suds reaching a predetermined level through a circuit to be later described. When closed, switch 636 connects with line 637 which in turn connects with lines 560 and 561 which lead directly to the motor 562 of the master timer. As already shown, the other side of the line is connected through lines 563 and 564 with the other current line 517.

Soap cut-off and start of timing motor

It will now be seen that by originally closing contacts 570 and 571 associated with the washer cam set, a multiplicity of actions occur simul-

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taneously. First, the dump valve is closed and the water is introduced at the desired temperature as determined by the thermal control mechanism. Furthermore, it should be noted that the timer is not yet operated so that the water continues to feed in until it reaches the level of the single pole, double throw switch 500 associated with the lower diaphragm, at which time the water cuts off and the soap and alkali start to feed in, either in admixture or separately, or by a combination of these feeding actions.

The soap feed continues until the level of the intermediate diaphragm is reached, at which time a circuit is closed which serves to energize the coil 640 of the multiple relay 616.

The circuit for accomplishing this action is as follows: One side of the coil 640 is connected to the current line 517 through lines 577 and 641. The other side of the coil is connected through line 642, terminal element 643 and line 644, the latter of which connects with contact element 645. Contact element 645 is adapted to engage the contact element 646 when the middle diaphragm is lifted, so that the current passes into the line 647 which returns through terminal 648 and line 649 to the line 551 which in turn connects with the other current line 518 through the switch element 549 of the double solenoid relay 550.

Thus, when the suds level reaches the predetermined height, the coil 640 of the relay 616 is energized and the relay switches 615 and 636 are moved to the dotted-line position shown in Fig. 16. As previously indicated, this will serve to break the circuit to the soap feeding valve and cause the flow of soap to be discontinued, and at the same time close the circuit, previously described, to the timing motor, whereupon the timing motor will start to operate.

It will further be noted that the timer motor thus started will continue to operate so long as contact switch 571 of the washer cam set and the contacts 610 and 645 of the suds level diaphragm switch 501 remain closed. As indicated on Fig. 18, contact switch 571 does remain closed until after the washer cam set has moved through approximately $326\frac{1}{4}$ degrees from zero position.

Such movement of the washer cam set serves to time the suds operation thus initiated, which will continue as described for the timed period.

It will also be noted that the contact switch 571 of the washer cam set serves to operate the multiple relay 624 which includes the switch 626 of the dump valve circuit, whereby the dump valve will remain closed throughout the suds period, namely, for approximately $326\frac{1}{4}$ degrees of movement of the washer cam set from zero position. Contact switch 571 also causes relay switch 627 of the multiple relay 624 to remain closed throughout substantially $326\frac{1}{4}$ degrees of movement of the washer cam set. This last-mentioned switch, as previously described, is in the timing motor circuit.

Suds photo-cell circuit

The washing thus continues under the timed influence of the washer cam set and nothing else occurs until the washer cam set has moved approximately $247\frac{1}{2}$ degrees from zero position. At this point, as will be observed from Fig. 18, the contact switch 668 is closed.

The purpose of this switch is to close a circuit which connects the photo-cell light 669 and the photo-cell proper 670 in a circuit which, under certain circumstances, is adapted to energize the

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operating coil 671 of the double coil relay 672, shown at the extreme left-hand side of Fig. 16. The photo-cell proper 670 is already adjusted on the basis of predetermined standards to respond to light transmitted through the transparent portion 506 of the bleed pipe 503, of a value which has been fixed as indicative of the degree of cleanliness desired to be accomplished by the suds operation.

The photo-cell proper 670 may be of any suitable type of construction. In view of the fact that these mechanisms are well understood in the electrical art, a detailed disclosure thereof is not made on the drawing, but rather this mechanism is illustrated diagrammatically by the symbol designated 670 on Fig. 16B. It is to be understood that this diagrammatic representation is intended to include all mechanism necessary for proper operation of the photo-cell, such as, for instance, a relay, as well as suitable amplifying circuits if the type employed requires such devices.

The circuit for effecting this operation is as follows: The contact switch 668 of the washer cam set causes current to pass from the current line 551 into line 673 to energize the coil 674 of the relay 675. The other side of the coil is connected through line 576, which in turn connects with the other current line 517 through line 577. The energizing of the relay coil 674 causes the relay switch 677 to move to the full-line position shown in Fig. 16.

It will be noted at the outset that one end of this switch is connected through line 678 with the current line 582 previously described. The other side of the relay switch 677 connects with line 679 which passes to the right and thence downwardly to a manually operable switch element 680, the other side of which is connected to line 681 which passes upwardly and connects to the terminal element 682. The terminal element 682 in turn connects with line 683 which connects with the light 669 of the photo-cell proper 670. This line further connects through line 684 with the photo-cell proper 670. The other side of the photo-cell light 669 connects through line 685 to the other current line 597. The other side of the photo-cell proper, however, connects through line 686 with terminal 687, the other side of which connects through line 688 with the relay coil 671 of the double coil relay 672 shown on the left-hand side of Fig. 16.

Operation of suds photo-cell

As previously described, the photo-cell proper 670 is adjusted to complete the above-described circuit when a predetermined quantity of light is projected thereon through the transparent section 505 of the bleed pipe 503. When the wash liquid passing through the bleed pipe 503 contains solid matter, such as dirt, which prevents the passage of the desired quantity of light, this circuit is not energized and consequently the solenoid 671 above referred to is likewise not energized. It should be understood at this point that until the solenoid 671 is energized by the photo-cell mechanism in the manner above referred to, when the apparatus is operating automatically, the washer cam set will continue to function in the manner heretofore described without interruption, with the result that a series of successive suds operations are performed. It will be apparent, however, that such repeated suds operations will be effective to remove more and

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more soil from the clothes, and thus a time will arrive, during a particular suds operation, when the washing liquid passing through the bleed pipe 503 will be sufficiently free from solid material to permit the passage of a quantity of light to the photo-cell 670 sufficient to energize the above-described circuit and, as a result, the coil 671 of the multiple coil relay 672.

When coil 671 is so energized, it will act to move the switch element 689 from the full-line, normally open position, as shown in Fig. 16, to the dotted-line position, the effect of which is to condition a circuit to be later described which acts to energize the relay coil 690 of the double coil multiple relay 550 shown just below the relay 672.

When the last-named relay coil 690 is energized, all current to that part of the control mechanism which is operated by the washer cam set is disconnected, and the current is shifted to the mechanism operated by the rinsing cam set 541. This shifting, however, does not occur until the completion of the final suds operation, as will be described in a moment.

From an inspection of Fig. 18, it will be noted that the contact switch 668 of the washer cam set remains in contact for approximately $78\frac{3}{4}$ degrees of movement of the washer cam set, or, in other words, for a period of approximately 70 seconds. This may be determined by the fact that contact 668 is made for the period of seven teeth on the ratchet which are impulsed at 10 second intervals. As a result, the photo-cell mechanism is connected and held in operation for approximately 70 seconds in order that sufficient time may be had to permit amplifying tubes of the photo-cell circuit (if such are used) to become thoroughly warmed up to their proper condition for accurate functioning. If at any time during the interval of 70 seconds sufficient light passes to the photo-cell as above indicated, the relay switch 689 previously referred to will be moved.

Here again it should be noted that the relay mechanism 672 is of the type which remains in its existing position until the opposite coil is energized. Thus it will be seen that when relay switch 689 is once moved it will remain in closed position until it is reset in the manner herein-after described, which resetting, incidentally, occurs much later in the operation.

Direct timer connection

Just before the washer cam set is moved to the point where the dump valve will open, the timer motor circuit previously described is broken. Long before contact switch 571 is broken, however, a new contact 545 has been made. As previously suggested, the purpose of this contact 545 is that of establishing an auxiliary or direct timing motor circuit which causes the timing motor to continue in operation notwithstanding the fact that the other circuit for the timer is broken. The breaking of this last-named circuit will necessarily occur when the machine is dumped, and as it is necessary to continue the movement of the washer cam set to time the dumping period and to cause the washer cam set to move to its final and last position, this new and direct circuit is required.

It will be noted from Fig. 18 that contact 545 remains closed for three additional notches of the ratchet, or, in other words, until the washer cam set comes to its final position at segment 544.

The direct circuit for operating the timing motor through contact switches 545 is as follows:

Current line 551 connects through contact switch 545 to line 557 which passes through switch element 558 of the multiple switch relay 550 and thence through line 559 to line 560, to which last-named line the timing motor is connected through line 561. The other side of the timing motor is connected through lines 563 and 564 to the other current line 517. It will be apparent that even after the other timer motor circuit controlled by contact switch 571 is broken, the timer will continue to run and thus move the washer cam set on to its final position.

Shifting to rinsing cycle

When the washer cam set comes to its final position at segment 544, contact switch 546, previously referred to, is closed. This switch serves to connect the current line 551 with the line 692 which connects through the switch 689 of the relay 672 with the line 693. The result is that the coil 690 of the lower relay 550 is energized as the other side of this coil is connected through line 694 with the other current line 515.

It will be noted that the energizing of the coil 690 depends upon the previous closing of the switch 689 which, as already described, in turn depends upon the operation of the photo-cell 670 in the manner above pointed out.

Consequently, when the correct number of suds operations have been performed, the movement of the washer cam set to its final segmental position causes the two switches 549 and 558 to be moved so as to break the flow of current to the current lines 551 and 560, respectively. On the other hand, switch 549 in its new position connects the current line 548 with a new current line 695 which supplies current to that portion of this mechanism which controls the rinsing operations.

In those cases, however, where the photo-cell has failed to cause a movement of the relay switch 689 of the relay 672, switch 549 is not so shifted and consequently the closing of contact switch 546 at the final position of the washer cam set is without effect. In such event, the timing motor remains connected and in operation through the maintenance of the direct circuit by means of contact switch 545 of the washer cam set, and hence the washer cam set will be moved by the timer to the segmental position represented at 556 in Fig. 18, and as a result thereof an entirely new and duplicate suds operation will be effected.

It will further be seen that such suds operation will be repeated any number of times that may be required to fully clean the clothes, and that the suds operations will not be discontinued until a clean-clothes condition, based on predetermined standards, is indicated by the photo-cell.

Breaking timer circuit on shift to rinse

When relay 550 is shifted, as above indicated, to connect the rinsing mechanism and relay switch 558 is moved to the "off" position, this action serves to break the direct current line to the timer and consequently all current to the timing motor, coming from that part of the mechanism controlled by the washer cam set, is shut off. However, the timer does not stop at this point for the reason that it is immediately energized through a new circuit which is created by relay switch 549 which is shifted to connect the current with line 695.

Rinsing operation

Assume now that the desired number of suds operations have been carried out and that the relay switch 549 has been shifted, as above indicated, to throw the current into line 695 and to disconnect that part of the mechanism controlled by the washer cam set. It will be apparent that the current in line 695 will flow through the switch element 696 of the multiple relay 697 and into line 698. From line 698 current will flow into line 699 and through switch element 700 of the relay 697 and into line 701. It will be noted from Fig. 16 that line 701 passes through the contact switch 702 of the master timer 543 and thence through line 703 into the solenoid 704 which controls the movement of the rinse cam set 541. The other side of the solenoid 704 is connected through lines 705 and 706 with line 517, which is the other current line.

If it should happen that the contact switch 702 of the master timer 543 is in such position as to make contact (see Fig. 17), then it will be apparent that the solenoid 704 will at once be energized to cause the rinse cam set to be moved one tooth space, or, in other words, from segment 708 to segment 709. If it should occur, however, that the contact switch 702 of the master timer is in open position, it will nevertheless soon make contact for the reason that the timer motor is energized by a new circuit which is created when the relay 550 is shifted from washing to rinsing position.

It will assist in an understanding of this new circuit to first observe from Fig. 19 that the rinsing cam set, when at rest at the end of a rinsing operation, is in the position of segment 708. In this position, contact switch 710 is made, whereby the circuit controlled thereby is closed. Thus, current which passes through the relay switch 696 into line 698 is free to pass into line 711 which constitutes the bus-bar for the rinse cam set, and that from the bus-bar the current passes through contact switch 710 into the line 712 which passes through the switch 713 of the multiple switch relay 697 and into line 714. Line 714 connects with line 715 which in turn connects with line 560 previously referred to.

It will be noted from Fig. 16 that the timing motor 562 is connected between line 560 and the other current line by means of lines 561 and 563, respectively. Accordingly, if the rinse cam set is not already given an impulse of movement by the solenoid 704, the movement of the timing motor through the circuit just described will, within the course of a few seconds, bring the contact switch 702 of the master timer into closed position, whereupon the solenoid 704 will be energized so as to move the rinse cam set from the segment 708 to segment 709, as shown in Fig. 19.

Starting the rinsing operation

When the rinse cam set is moved to the position of segment 709, it will be noted from Fig. 19 that contact switches 716 and 717 are closed. The effect of closing switch 716 is to cause current to pass from the bus-bar 711 into line 718 and through the coil 719 of the multiple relay switch 720. The other side of the coil 719 is connected through line 721 to the line 706 which in turn connects to the other current line 517. In consequence, relay switches 722 and 723 of the relay 720 are moved to closed or full-line positions, as shown in Fig. 16.

Similarly, the closing of contact switch 717 of the rinse cam set causes current to pass from

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the bus-bar 711, through line 724 into the coil 725 of the multiple relay 726. The other side of coil 725 is connected through lines 727 and 728 to the line 706 which leads back to the other current line 517. The energizing of relay coil 725 causes the relay switches 730 and 731 to be moved

The result of these actions is to close a multiplicity of circuits simultaneously, which cause the following events to occur:

- (1) Close the dump valve;
- (2) Turn on the water by means of a circuit which is under the control of the highest diaphragm-operated switch 502;
- (3) Connect the thermal control mechanism so that the water will be adjusted to the desired temperature; and
- (4) Condition a circuit for operating the timing motor, which will be finally closed when the water is turned off.

Thus, the timing motor will be started at the time the water valve is closed. These various circuits will now be described.

Closing dump valve

The closing of the dump valve is caused by the movement of the relay switch 730 of the multiple relay 726. It will be noted that one side of switch 730 is connected through a line 732 with the current line 698. The other side of switch 730 connects through line 733 with line 629 which, as previously described, serves to energize the control mechanism which closes the dump valve.

Conditioning timer motor circuit

This circuit is conditioned by the closing of the relay switch 731 of the relay 726 which is likewise connected to the current line 698 through line 732. The other side of the relay switch connects through lines 734 and 735 with relay switch 736 of the multiple relay 737. This relay is normally open and will not be closed until the water is shut off and consequently the circuit now being described will not function to start the timing motor until later. However, the relay switch 736 is adapted to have its other end connected with line 738 which extends downwardly and connects with line 560 which serves to connect the timing motor 562 through line 561 as previously described.

It will thus be seen that when relay switch 736 is closed, the timing motor will be started, as will be pointed out with more particularity later. At this point, however, it should be noted that the timing motor circuit just referred to has been conditioned by the closing of the relay switch 731.

Opening water valve

The opening of the water valve is effected by closing relay switch 722 of the relay 720. One side of this switch is connected through line 739 to the current line 698 previously described. The other side of switch 722 is connected through line 740 with line 741 which connects with switch 742 of the relay 737. Switch 742 is normally in closed position, as shown in Fig. 16, whereby the current is free to pass into line 743 which connects with one side of the manually operable switch 744, shown at the lower central portion of Fig. 16A. The other side of switch 744 connects with line 592 previously described.

It will be noted from Figs. 16A and 16B that line 592 connects through the terminal 593 with the water valve control line 594 which extends directly to the water valve control mechanism

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without, however, including the lower diaphragm-operated switch 500 in its circuit. In other words, this circuit will not be interrupted to shut off the water valve when the water level reaches the height of the lower diaphragm, as was the case in connection with the suds operations previously described. This is because during the rinsing operation it is preferred to maintain a water level at substantially the height of the upper diaphragm, as shown in Fig. 16B.

The upper diaphragm switch 502 will be effective in this instance to shut off the water, as will hereinafter be more fully described. It will be apparent, however, at this point that the closing of the relay switch 722 will serve to open the water valve so that the water will be fed into the washing machine.

Automatic thermal control mechanism

In addition to the foregoing, relay switch 723, which is likewise connected to the current line 739, is closed, whereupon the current passes therethrough and into line 745. It will be noted from Fig. 16 that line 745 connects with line 598 which, as previously indicated, is the main current line extending to the automatic thermal control mechanism 603. Thus, the automatic thermal control mechanism is connected for operation throughout the entire period during which the water is flowing into the washing machine and that, as a matter of fact, the thermal control mechanism circuit is closed for the entire period during which the rinsing cam contact switch 716 is closed.

As a result of the foregoing operations, the dump valve is closed and the water at the desired temperature is fed into the washing machine. At the same time the timer motor circuit has been conditioned, as previously indicated.

Water shut-off and starting of timing motor

The water continues to feed into the washing machine until the level thereof reaches the level of the uppermost diaphragm associated with the washing machine, or, in other words, the diaphragm which controls the switch mechanism 502.

It should be understood at the outset that the water valve will be closed by the movement of the switch 742 of the relay 737, which is effected when the relay coil 746 is energized. This coil is so energized when the contact elements 747 and 748 of the upper diaphragm switch 502 are closed, whereby the water will be cut off when it has reached the level of the diaphragm associated with the upper switch 502.

The circuit for energizing relay coil 746 will now be described. Contact 747 is directly connected with current line 698, previously described, as follows: It will be noted from Fig. 16 that line 739 connects with current line 698 and then extends through terminal 749 and connects with line 750. Line 750 extends upwardly and connects directly with contact element 747. As a result, when contact 748 connects with contact 747, current passes therethrough into line 751, and then passes through terminal 752 into line 753 which connects directly with the relay coil 746. The other side of the relay coil is connected through line 754 with line 706 which extends to the other current line 517.

It will thus be apparent that when the water reaches the level of the uppermost diaphragm, the contacts 747 and 748 will be closed, with the result that the relay coil 746 is energized. The en-

energizing of the coil 746 of the relay 737 causes the relay switches 742 and 736, as well as the additional relay switch 755, to be moved to the dotted-line positions shown in Fig. 16. The result of this movement is, first, to cut off the water by switch 742 breaking the water feed circuit; secondly, to start the timer motor by the closing of the switch 736 which completes the timer motor circuit previously described; and thirdly, to cause the introduction of bleach into the washing machine by closing switch 755 through a circuit which will now be described.

Feeding of bleach

One side of the relay switch 755 is connected to line 741 through line 756. It will be recognized that line 741 will be connected to the current line 698 so long as relay switch 722 of the relay 720 is in closed position, and that relay switch 722 will be closed so long as the contact switch 716 of the rinse cam set remains closed, or, in other words, until the rinse cam set is moved to the next segmental position under the influence of the timer motor.

The closing of contact switch 755, therefore, causes current to pass into line 1361, through relay switch 1350, and into the relay coil 758 of the multiple coil relay 759. At this stage in the operation, relay switch 1350 is in dotted-line or closed position. Relay 759 is equipped with a reset coil 760 and a switch element 761, and is of a type in which the switch element remains in its existing position until the opposite coil of the relay is energized. This relay switch is normally in the dotted-line or open position, as shown in Fig. 16. The other side of the upper coil 758 of the double coil relay 759 connects through lines 762 and 763 with the other of the current lines 517. As a result, when the relay switch 755 of the relay 737 is closed as above indicated, the upper coil 758 of the multiple coil relay 759 is energized, whereby the switch 761 thereof is moved to the full-line or closed position as shown in Fig. 16.

The closing of switch 761 causes current to pass therethrough from the bus-bar 711 into line 764 which connects with the manually operable switch 765, the other side of which is connected through line 766 with the terminal 767. The other side of this terminal connects with line 768 which extends to the operating solenoids associated with the upper and lower bleach control valves 769 and 770, respectively. The other sides of these solenoids are connected through line 771 with current line 597 which, as previously described, is connected with the other current line 517. Accordingly, as a result the bleach contained in tank 772 is introduced into the rinse water. In this connection, it should be understood that all of the measuring tanks shown in Fig. 16B are provided with suitable vent pipes 773, as indicated on the drawing.

By virtue of the fact that relay 759 remains in its existing position until it is reset, the solenoids associated with the bleach valves 769 and 770 remain energized, whereby the lower valve remains open and the upper valve remains closed. Besides, relay switch 1350 of relay 759 will shortly be opened, as will be later pointed out. This prevents additional bleach from being fed into the measuring tank 772 and assures that only one charge of bleach will be fed into the washing machine prior to the time that switch 761 of the relay 759 is reset to open position. Such resetting requires that the opposite relay coil 760 be

energized, which will occur at a later time in the operation, as hereinafter pointed out.

Starting timing motor

As already indicated, the closing of the switch 736 of the relay 737 serves to complete the timer motor circuit, whereupon the timing motor starts to operate at the same moment that the flow of water into the washing machine is cut off. As a result, solenoid 704 of the rinse cam set is energized under the direct influence of the master timer, whereupon the rinse cam set is moved from the position represented by segment 709, shown in Fig. 19, to the next segmental position. This movement serves to break contact switch 716, with the result that relay switches 722 and 723, respectively, of the relay 720 are moved under the influence of a spring to the dotted-line or open circuit position.

It will be noted, however, from Fig. 19, that contact switch 717 remains closed, whereupon the dump valve likewise remains closed. Furthermore, the timing motor circuit, which depends on relay switch 731, remains closed and the timing motor circuit thus remains established so long as the relay coil 746 of the relay 737 continues to be energized. It will be apparent that this relay coil 746 will continue in this energized state so long as the water level remains sufficiently high to cause the contacts 747 and 748 associated with the upper diaphragm switch 502 to remain in contact. With the circuits thus established, the rinsing operation is initiated and will continue throughout that period during which the rinse cam set is moving through approximately 306 degrees from zero position.

Direct timer circuit

As already stated, the timer motor does not start to operate until the water is shut off. However, immediately upon starting the timer motor the rinse cam set moves to the next segmental position, at which time contact switch 710 of the timer cam set is made. As previously described, this contact switch 710 establishes a direct circuit for the timer motor whereby the timer motor is now also energized through the direct circuit in addition to the above-described timer motor circuit which is under the control of the upper diaphragm level switch. In consequence, any variation that may occur in the water level in the washing machine will not cause the timing motor to stop operating. This assures that the timing of the rinsing operation is carried out in the intended manner.

Rinse photo-cell operation

Nothing more occurs in the rinsing operation until the rinse cam set has been moved through approximately 198 degrees from zero position, at which time it will be noted from Fig. 19 that contact switch 774 is closed. The function of the circuit established by contact 774 is that of connecting the other of the two photo-cell devices, namely, the photo-cell light 775 and photo-cell proper 776 in circuit with the lower relay coil 777 of the multiple coil relay 795, for the purpose of moving the relay switch 778 to closed position as shown in Fig. 16.

The circuit for so connecting the photo-cell light 775 with photo-cell proper 776 is as follows: The closing of contact switch 774 causes current to pass from the bus-bar 711 into line 780 through the coil 781 of relay 782 and through line 783 to the other current line 728. This causes the

relay switch 784 to be moved to closed or full-line position, as shown in Fig. 16, which serves to connect the current line 698, previously described, with line 785. Line 785 connects with manually operable switch 786 which in turn connects with line 787 which connects with terminal 789. The other side of terminal 789 connects with line 790 which in turn connects directly with the photo-cell light 775 and also with the photo-cell proper 776. The other side of the photo-cell light 775 connects through line 791 with the other current line 597, which, as previously shown, is connected with the current line 517. The other line 792 from the photo-cell proper 776 connects through terminal 793 with line 794 which connects directly with the lower relay coil 777 of the relay 795. The other side of the coil 777 is connected through line 796 with the other current line 564.

It is to be understood that the photo-cell mechanism 776 may be of any suitable construction but is here represented only diagrammatically by a symbol which is intended to identify any suitable type of photo-cell device, including a relay, amplifying tubes, and other mechanism if such is necessary.

It should be further understood that the photo-cell mechanism 776 is one which has been previously adjusted, on the basis of predetermined standards, to be responsive to an amount of light passing through the transparent section 505 of the bleed pipe 503, which is indicative of a substantially soap-free condition of the water passing therethrough.

The photo-cell 776 operates on substantially the same principle as that involved in the operation of the photo-cell 670, except that its sensitivity is so adjusted that it operates at a time when the rinsing operation has been carried to that point, fixed by predetermined standards, as complete. It is apparent that when this point is reached, the circuit above described is energized by the photo-cell 776, and that in turn the relay coil 777 of the multiple coil relay 795 is energized, and that as a result the relay switch 778 is moved to closed position as shown in Fig. 16. This multiple coil relay is of a type in which the switch remains in its existing position until the opposite coil is energized, and consequently, when the switch 778 is moved to closed position as above indicated, it will remain in such closed position until the opposite coil 797 is energized, as when resetting in a manner hereinafter described.

The effect of closing switch 778 is that of conditioning a circuit which will subsequently be closed when the rinse cam set has been moved to the completion of the cycle and the contact switch 798 of the rinse cam set is closed.

From the above description, however, it is apparent that the photo-cell mechanism will not operate unless the rinse water passing through the bleed pipe 503 is sufficiently clear to indicate, on the basis of predetermined standards established therefor, that the rinsing has been completed. If this degree of clarity is not reached at the end of the first rinsing cycle, it is apparent that the movement of the rinse cam set will be continued by virtue of the fact that the direct timer circuit is maintained up to and including the last segmental position indicated as 708 on Fig. 19, and the further fact that this connection of the timer cycle will be effective to move the rinse cam set to the next segmental position indicated as 709 on Fig. 19 in exactly the same manner as previously described in connection

with the commencement of the rinsing cycle. The result, therefore, will be that the rinsing cycle will be repeated with the exception, however, that bleach is not introduced on the successive treatments for the reason that the double coil relay 759 has not yet been reset. In other respects, however, the rinsing cycle will be carried out and repeated as many times as may be required until the desired degree of clarity of the rinsing water permits the photo-cell mechanism 776 to operate and throw the switch 778 in the manner above indicated.

In addition to the foregoing, when relay coil 777 is energized, relay switch 1350 of relay 795 is moved to open position whereby the bleach-feeding circuit is broken and the feeding of bleach is thus prevented until relay 795 is reset in the manner hereinafter described.

Switching to sour and blue operation

When the shift from the rinsing cam mechanism to the blue and sour mechanism is made, it is necessary to have the blue and sour cam set already in the position indicated on Fig. 20 as segment 799, or, in other words, in its first operating position. The normal position of rest, however, for the blue and sour cam set is in the segmental position 800 immediately ahead of the segment 799 and, therefore, it is necessary during the last rinsing cycle to provide for the automatic movement of the blue and sour cam set to the starting position as indicated. For this purpose, a circuit is provided which is connected in parallel with the coil 777 of the relay 795, whereby the solenoid 801 of the blue and sour cam set 542 receives an impulse when the photocell 776 operates to energize the coil 777.

This circuit is shown in Figs. 16 and 16A, from which it will be noted that the line 794, which connects with the coil 777, also connects with a line 802 which in turn connects with the switch 803 of the multiple relay 697. The other side of the switch 803 connects with line 804 which in turn connects with line 805. Line 805 connects with the solenoid 801 of the blue and sour cam set. The other side of the solenoid 801 connects through line 806 with the other current line 517.

Inasmuch as the multiple relay 697 is initially in a position to complete the circuit just described, that is to say, with the switch 803 in closed position, it will be apparent that simultaneously with the movement of the switch 778 under the influence of the photo-cell 776, the solenoid 801 of the blue and sour cam set will be energized, with the result that the blue and sour cam set will be moved from the segmental position 800, as shown in Fig. 20, to the segmental position 799. Thereafter, the rinse cam set finally moves to its end position where contact switch 798 is closed and, as a result, current passes from the bus-bar 711 through line 807, through the closed relay switch 778 just described, and into line 808. From line 808 the current passes into line 809 and into the lower solenoid 810 of the double solenoid relay 697. The other side of the coil 810 is connected through line 811 to the current line 564 previously described, which finally connects with the other current line 517.

It will thus be seen that in the particular rinse operation which the photo-cell indicates to be the last, the final position of the rinsing cam causes the upper of the relay switches of the relay 697 to be moved from the full-line position as shown on the drawing to the dotted-line position. This movement of the five relay switches

is effective to make various circuits and to break various previously established circuits, all as will now be more specifically described.

Breaking direct timer circuit on rinsing cycle

The top relay switch 713, which was previously closed to establish the direct circuit to the timer motor 562, is moved downwardly so as to break this circuit. In consequence, the timer motor is no longer operated through this direct circuit connection.

Shifting the current line connection from rinsing cam set to blue and sour cam set

When the relay switch 696 moves to the dotted-line position it serves to break the connection between the current line 695 and the current line 698 which supplies current to the rinse cam set and the other mechanism operated thereby. At the same time, switch 696 connects the current line 695 to the new current line 812 which constitutes the main current line for feeding the blue and sour cam set and the associated mechanism operated thereby.

Breaking initial impulse circuit for blue and sour cam set

Similarly, relay switch 803 is moved to open or dotted-line position, whereby the direct current previously described, which was effective to energize the blue and sour solenoid 801 for one impulse, is broken.

Disconnecting rinse cam set solenoid circuit

In addition, relay switch 700 is moved to dotted-line or broken position, which serves to disconnect the circuit extending from the current line through the timer switch 702, and on to the rinsing cam set solenoid 704. Thus, not only is the timing motor circuit disconnected, but at the same time the source of current passing through the timer and extending to the rinse cam set solenoid is likewise disconnected.

Connection of blue and sour cam solenoid

At the same time, the lowermost switch 813 of the multiple relay 697 is moved to closed position, which serves to connect the blue and sour solenoid 801 with the current source through the master timer, whereby the blue and sour cam set will be operated through this circuit by the timer when the timer motor is running.

This circuit is as follows: Line 814 connects with the new current line 812 and extends up to the relay switch 813 which, as above indicated, is now moved to dotted-line or closed position. The other side of the switch is connected through line 815 with the timer switch 816 which is shown in Figs. 16 and 17. The other side of the timer switch is connected to line 805, previously described, through line 817, which, as already indicated, extends to the solenoid 801 of the blue and sour cam set 542. Accordingly, when the timer motor is started, the blue and sour cam set will be operated.

Starting blue and sour treatments

As already stated, the timing motor has been shut off and consequently is not operating at the time the current is shifted to the new current line 812 which supplies the blue and sour cam set. Furthermore, the blue and sour cam set has been moved from the segmental position 800 on Fig. 20 to segmental position 799. When current is supplied to line 812, it will pass into line 818 from which it passes into line 819 which

serves as the bus-bar for the blue and sour cam set. When the blue and sour cam set is in the position of segment 799, as shown in Fig. 20, contact switches 820 and 821 are closed. Accordingly, the current immediately passes through contact switch 820 into line 822 and through relay coil 823 of the multiple relay 824 and through line 825 back to the other current line 517. Similarly, current passes through contact switch 821 into line 826 through relay coil 827 of the relay 828 and through lines 829, 830 and 825, back to the other current line 517.

It will be noted from Fig. 16A that when the relay coil 823 is energized, it acts to move four relay switches from open, dotted-line position to full-line closed position. It will also be noted that the energizing of relay coil 827 serves to close the relay switch 831 of the relay 828.

Closing dump valve

The effect of closing relay switch 831 is that of closing the dump valve. The circuit by which this is accomplished is as follows: One side of switch 831 is connected through line 832 with line 833 which in turn connects with the current line 818 previously described. The other side of switch 831 connects with line 834 which extends up and joins line 629 which, as previously described, extends to the mechanism which operates to close the dump valve. Consequently, the dump valve is immediately closed and remains closed so long as the relay switch 831 remains closed.

Opening and closing water valve

The closing of relay switch 835 of the multiple relay 824 serves to connect the contact 747 of the switch 502 associated with the upper diaphragm, with the current line. This is accomplished by current passing from current line 818 through line 836, through the switch 835 and into line 837 which connects with the line 739 which, as previously described, connects through line 739 and terminal 749 with line 750. Line 750 leads directly to the upper contact 747 of the upper diaphragm switch. Through this connection the upper diaphragm switch is connected for controlling the shut-off of the water and the feeding of blue in a manner hereinafter described.

At the same time, relay switch 838 is closed and serves to connect the current line 818 through line 839 with line 840 which extends to the left as shown in Fig. 16, and connects with line 741 which, as previously described, constituted a part of the circuit which was active in turning on the water valve during the rinsing operation. In consequence, the closing of relay switch 838 serves to open the water valve in exactly the same manner that the closing of switch 722 opened the water valve in the rinsing cycle. It is to be particularly noted that the rinsing cycle utilized the upper diaphragm water level, whereby the water was cut off by the upper diaphragm switch 502 in exactly the same manner as will be accomplished in the first portion of the blue and sour cycle, or, in other words, that portion thereof which serves to blue the clothes. It should be noted, however, that in connection with the blue operation now being described, the current to the upper contact 747 associated with the upper diaphragm switch 502 is supplied through its own circuit under the control of relay switch 835 described above.

The operation thus far described, therefore, operates to close the dump valve and turn on the water, but it will be noted that the thermal con-

trol mechanism is not connected at this stage of the operation, and consequently the water which is fed to the washing machine is cold. The water continues to flow into the washing machine until it reaches a level of sufficient height to operate the diaphragm associated with the upper switch 502, at which time the contact 748 is caused to engage the contact 747. As previously described, contact 747 has been connected to one of the current lines by means of relay switch 835 of the multiple relay 824, and consequently current passes through the upper diaphragm switch 502 and into line 751.

Feeding blue

As already described in connection with the rinsing operation, line 751 serves to energize the relay coil 746 of the multiple relay 737 which in turn serves to move the relay switch 742 from the full-line or water feeding position to the dotted-line position in which it disconnects the water feeding circuit and connects the current supplied thereto with the new line 841. This new line 841 is a part of a circuit for feeding blue into the washing machine, and consequently it is to be noted that immediately upon the water circuit being disconnected the current line which supplied the water feeding circuit is now connected to and supplies line 841 of the blue feeding circuit.

Line 841 connects with relay switch 842 of the multiple relay 824 which is now in closed position, as previously indicated. It may be noted, however, that prior to the operation of the bluing treatment now being described, the relay switch 842 was opened and consequently the connection of the current through switch 742 of the relay 737 with line 841 during the rinsing cycle was of no effect. During the bluing operation, however, the current that passes through switch 842 passes into line 843, through manually operable switch 844 into line 845, through terminal 846 and into line 847. As shown in Fig. 16B, line 847 connects directly with the solenoids of the upper and lower valves 848 and 849, respectively, which are associated with the blue measuring tank 850. The other sides of the solenoids are connected, respectively, through line 851 with the other current line 597.

It will thus be seen that when the water has reached the level of the upper diaphragm switch 502, the relay switch 742 of the multiple relay 737 will be moved, as previously described, to the dotted-line position to cut off the water and to immediately energize the solenoids of the blue feeding valves, whereby the measured quantity of blue contained in the blue tank 850 will be discharged into the washing machine. Here again the lower valve 849 of the blue tank is a normally closed valve of the type illustrated in Fig. 8, whereas the upper valve is a normally open valve of the type illustrated in Fig. 7. Also, the blue tank is vented by any suitable means, such as the upstanding pipe 773.

Closing circuit to timer motor

At the same time that relay switch 742 of the multiple relay 737 is moved under the influence of the higher diaphragm switch 502 to cut off the water and to feed the blue, the relay switch 736 is also moved to the dotted-line or closed position. This serves to energize the timer motor in substantially the same manner as described in connection with the rinsing operation, with the exception, however, that the current is supplied to

line 735 through line 852 which in turn derives its current through line 853, relay switch 854 and line 855. It will be noted from Fig. 16 that line 855 is an extension which connects with current line 818 previously described. Consequently, the movement of the relay switch 854 of the multiple relay 824 conditions the timer circuit just referred to, which is finally completed by the closing of the relay switch 736 under the direct control of the solenoid 747, which operates when the water reaches the level of the diaphragm associated with the upper switch 502.

From the foregoing, it will be seen that the water is cut off at the level of the upper diaphragm and that simultaneously therewith the desired quantity of blue is introduced into the washing machine, and at that same moment, the timing motor is started. As already indicated, however, the solenoid 704 of the rinse cam set has been disconnected from the master timer and the solenoid 801 of the sour and blue cam set has been connected thereto, whereby the movement of the timer at this point in the operation is effective only to advance the blue and sour cam set. Accordingly, the blue and sour cam set is moved from the first segmental position 799 to the next segmental position, as shown in Fig. 20.

It will be noted from Fig. 20 that contact 820 remains closed for four solenoid movements of the blue and sour cam set or, in other words, for approximately 41 degrees of movement from zero position. This is not absolutely essential but is preferred in this particular embodiment. In addition, contact switch 821 remains closed for approximately 164½ degrees of movement of the blue and sour cam from zero position, whereby the dump valve remains closed during the period of this movement. In consequence, the bluing operation continues under the timed control of the timer as established by the blue and sour cam set.

Establishing direct timer circuit

After the blue and sour cam has moved three solenoid impulses or, in other words, approximately 30¾ degrees from zero position, contact 856 is established. Contact switch 856 of the blue and sour cam set is effective to establish a direct circuit for operating the timing motor so that from this point on to the completion of the bluing treatment the timer motor may be operated directly without depending upon the previously described circuit which was utilized to start the timing motor at the time the water was cut off.

This circuit is as follows: First, current passes from the bus-bar 819 through contact switch 856 into line 857, and through relay coil 858 of the relay 859 which serves to move the relay switch 860 to the full-line position as shown in Fig. 16A. The other side of the relay coil 858 is connected directly with the current line 830. One side of the relay switch 860 is connected directly with current line 833 and the other side thereof connects through line 861 with line 560 which, as previously described, establishes a circuit with the timing motor 562 through line 561, the other side of the timing motor being connected to the other current line through line 563. Accordingly, the timing motor is operated by the direct current line until the blue and sour cam set is moved a total of approximately 185 degrees from zero position.

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Dumping blue

After the cam set is moved $164\frac{1}{2}$ degrees from zero position the contact switch 821 is broken, as previously indicated, whereby the dump valve is opened and the contents of the washing machine are discharged. The dump valve remains open for the next two impulses of the blue and sour cam set solenoid so that the dumping interval is under the time control of the master timer. However, after the cam set is moved approximately 185 degrees, the next impulse of movement causes the blue and sour cam set to move to the position represented by segment 862, in which position the direct timer circuit, controlled by contact switch 856, is broken.

Starting sour treatment

At the same time, however, contact switch 821, which controls the dump valve circuit, is again closed, and new contact switch 863 is also closed. The closing of contact switch 821 serves to close the dump valve in exactly the same manner previously described, and, therefore, it will not be described again. However, the feeding of the water and the other operations following the water feed are different, for the reason that it is desired in the sour treatment to use a smaller volume of water or, in other words, water brought to the level of the diaphragm associated with the lower of the three switches.

From an inspection of Fig. 16A, it will be observed that the closing of switch 863 serves to energize relay coil 864 by means of current passing from the bus-bar 819, through line 865 and coil 864 of the multiple relay 866 and thence through line 867 which connects with the other current line 830. Energizing relay coil 864 serves to move the three relay switches 868, 869 and 870 from their normally open dotted-line positions to their full-line closed positions, as shown on the drawing. The closing of relay switch 870 serves to connect the current with the middle contact 588 of the switch 500 associated with the lower diaphragm and consequently to energize the mechanism for opening the water valve in a manner similar to the operation effected during the washing operations.

The connection just referred to is established through relay switch 870 by means of the following circuit: One side of the relay switch 870 connects through line 871, whereas the other side thereof connects through line 872 and extends up and connects with line 584 previously described. As already shown, line 584 ultimately connects with line 587 which in turn connects directly with the middle contact 589 of the switch 500 associated with the lower diaphragm. Furthermore, contact 589 of the switch 500 connects directly with the water valve control solenoids in the manner previously described in connection with the washing operations. It will thus be seen that upon the closing of relay switch 870 of the multiple relay 866, current will be fed to the control mechanism of the water valve through the switch 500 associated with the lower diaphragm. It will further be apparent that when the water reaches the level of the lower diaphragm, the contact 588 which is connected to the current line 587 will break connection with the contact 589, whereby the water valve will be shut off.

Feeding of sour

The closing of relay switch 869 serves to connect the current which passes through the contact 588 of the switch 500 associated with the

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lower diaphragm and through contact 610 when the diaphragm is lifted, with a circuit which operates to feed the sour. As previously shown in connection with the washing operation, the upper contact 610 referred to connects with line 611 which ultimately connects with line 613 which feed back to supply current for the soap feeding circuit previously described.

As the soap feeding circuit is associated with the washer cam set and the devices operated thereby, which are now inactive, the current passing back through line 613 does not influence the soap feeding mechanism but, rather, passes into line 873 shown in Fig. 16A, which is directly connected with one side of the sour control relay switch 869. In this way, current is fed through switch 869 and into line 874 which in turn connects with line 875. Line 875 passes through manually operable switch 876 and into line 877, which passes through terminal 878 and into line 879. Line 879 connects directly with the solenoids associated with the upper and lower valves 880 and 881, respectively, which serve to control the feeding of sour from the sour-measuring tank 882. The other sides of the solenoids referred to connect through line 883 with the other current line 597. The sour tank 882 is vented through suitable pipe 773, as described in connection with the other measuring tanks.

The lower valve 881 is a normally closed valve of the type illustrated in Fig. 8, and the upper valve 880 is a normally open valve of the type illustrated in Fig. 7.

It will thus be seen that when the water has reached the level of the lower diaphragm, the middle contact element 588 breaks contact with the contact element 589 and thereby cuts off the supply of water and at the same time makes contact with element 610 which causes the current to pass through the sour controlling circuit just described. The feeding of current to the relay switch 869 for causing the sour feeding circuit to operate is also employed to reset certain of the double coil relays which have been previously operated, as will hereinafter be more fully described.

Starting timing motor

It will be noted from Fig. 16A that the relay switch 868 of the multiple relay 866 is also connected to line 873 which supplies the current thereto from the upper contact switch 610 associated with the diaphragm-operated valve 500. Consequently, at the same time that the sour feeding circuit is energized, as previously described, current also passes through relay switch 868 and into line 560 for establishing an operating circuit with the timing motor. As a result, the closing of contact switch 856 of the blue and sour cam and the consequent closing of each of the relay switches 868, 869 and 870 first cause water to be introduced into the washing machine to the level of the lower diaphragm, at which time the water is shut off and immediately upon closing of the water valve the sour is discharged into the washing machine and the timing motor is put in operation.

As shown in Fig. 20, the blue and sour cam then starts to move, whereby, after it has advanced four solenoid impulses, contact switch 856, which establishes the direct timer circuit, is again closed in the manner similar to that described in connection with the blue operation. Here again it will be noted that the contact switch which controls the water feeding opera-

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tion remains closed for four impulses of the solenoid or, in other words, for approximately 41 degrees of movement, which is preferred in this form of the invention but is not essential thereto, other than to provide an overlap between the two circuits for operating the timing motor.

The sour treatment is thus carried out under the timed influence of the timer and blue and sour cam sets until the cam set has moved a total of approximately $339\frac{1}{2}$ degrees from zero position, at which time contact switch 821, which controls the dump valve, is broken and the dump valve is permitted to open. As a result, the sour liquid is discharged. Nevertheless, contact 856 is maintained, whereby the timed movement of the blue and sour cam continues until the cam set has returned to its last and final position indicated at segment 800 on Fig. 20. At this point, contact switch 884 is closed. The function of the circuit controlled by contact switch 884 is that of stopping the entire operation and resetting certain relays, as will now be described.

Final stopping operation

It will be noted from Fig. 16A that contact switch 884 serves to connect current lines 819 with line 885. This line 885 extends directly to solenoid 886 associated with the manually operable starting switch 516 shown at the extreme left-hand side of Fig. 16. The other side of the solenoid 886 connects through line 887 with line 694 which in turn connects with the other current line 517.

In consequence, the starting switch 516 is moved from full-line position to the dotted-line position shown in Fig. 16, whereby the main current lines 514 and 515, respectively, are disconnected from the entire control mechanism. As a result, all current utilized for the control mechanism is cut off and the machine is entirely dead. Also, the breaking of the main current line, as just described, causes the motor 529 of the washing machine to stop, because the operation thereof depends upon current being supplied through lines 525 and 526, respectively, to relays which maintain the current connection to the motor.

For convenience, the movement of the switch 516 to "off" position closes a circuit 888 which serves to light a signal light 889 which will provide an indication that the operation is terminated.

PRIOR RESETTING OPERATION

Resetting relay 697

In addition to the foregoing stopping operation, current from line 885 also passes down line 1300 and into the upper coil 1301 of relay 697, the other side of which is connected through lines 1302 and 564 with the other current line 517. This causes the resetting coil 1301 to be energized and the relay 697 to be reset to full-line position. This relay 697 is thus made ready for a subsequent washing operation.

Resetting relay 550

In addition to the foregoing resetting and final stopping operations, the current which energizes coil 886 of the main starting switch 516 also passes down on lines 898 to reset the multiple coil relay 550, shown at the extreme lower left-hand corner of Fig. 16. This is accomplished by current passing from line 885 into line 898 which energizes the coil 899 which has its other side connected through line 900 to the other current line 694.

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In consequence, at the same time that solenoid 886 is energized to finally stop the entire apparatus, relay coil 899 of relay 550 is energized, which causes the relay switches 549 and 558, respectively, to be moved from their dotted-line positions to the full-line or closed positions shown in Fig. 16. In other words, this relay is reestablished in a position whereby the current connection is made to the washer cam set and disconnected from the rinsing and blue cam sets. This, of course, serves to condition the mechanism for a following complete washing operation.

In conjunction with the operation of this form of the invention, it is to be noted that when current was passed through lines 808 and 809 and into coil 810, as occurred when the shift was being made from the rinsing operation to the blue and sour operations, this current also passed to the left into line 890 and served to energize the upper coil 891 of the multiple coil relay 672 shown at the left-hand side of Fig. 16. The other side of coil 891 is connected through line 892 with the other current line 694.

As a result, when the automatic control mechanism was shifted from the rinsing operation to the blue and sour operation, the multiple coil relay 672 was reset whereby the relay switch 689 was moved to full-line or open position.

Resetting of relay 759

At the same time that this occurred, current was passed from line 808 into line 893 which connects with the lower coil 760 of the double coil relay 759. The other side of coil 760 is connected through line 894 with line 762 which in turn connects through line 763 with the other current line 517. Accordingly, simultaneously with the shift from rinse to blue and sour operations and the resetting of the relay 672, relay 759 is also reset, with the result that the relay switch 761, which is connected in the bleach feeding circuit, is moved to the dotted-line or open position.

It should be noted at this point that the bleach feeding relay 759 was maintained closed during the entire rinsing operation or, in other words, during the period when the bleach feeding mechanism was connected with the active part of the control mechanism. Consequently, only one bleach feeding operation was effected. However, the resetting just described occurs simultaneously with the shifting of the mechanism from the rinse cam set to the blue and sour cam set, whereby it is ready for the next complete washing operation.

Resetting relay 661

Furthermore, at a later period in the operation, namely, when the lower diaphragm switch is moved to cut off the water and energize the sour feeding circuit as previously described, the current which is fed back from the lower diaphragm switch through line 613, relay switch 869 of the relay 866, and into line 874 also passes to the left on line 895 and connects with lines 896 and 897. The current which passes into line 896 energizes the lower coil 663 of the double coil relay 661 which in turn is connected to the other current line 564. This serves to reset the relay by moving switch 651 from the full-line or closed position to the dotted-line or open position. It will be recalled that this is the relay which controls the feeding of additional alkali during the washing operation, and consequently, resetting it as described makes it ready for performing in the next complete cycle of operation.

Resetting relay 795

The current which passes into line 897 serves to energize the coil 797 of the double coil relay 795, whereby the relay switches 778 and 1350 are moved to the dotted-line positions, whereby they are reset for the next complete operation.

SUMMARY FOR SECOND FORM

It will be observed from the foregoing description that a completely automatic control mechanism is provided for washing machines represented by the type here illustrated. It will be noted, however, from Fig. 16A that a series of manual switches are provided in the lower central portion of the drawing. These are designated as switches 653, 765, 844 and 876, respectively.

Manual cut-outs of agents

From the foregoing description it will appear that these switches provide means for manually breaking the circuits leading to certain control mechanisms associated with the washing machine. These are, respectively, the control mechanism for the additional alkali, control mechanism for the bleach, control mechanism for the blue, and control mechanism for the sour. It will, therefore, appear that if during any particular automatic operation one or more of these added substances is to be omitted, it is merely necessary to open the particular switch which controls the circuit in question.

Such switch movements, however, do not affect the other aspects of the automatic operation but merely result in the omission of the particular automatic feed which it is desired to eliminate.

As shown on Fig. 16A, each of the manually operable switches referred to has associated therewith a complementary switch element which serves to close one of a series of lights 901 which are connected across the current lines, which will quickly show that the particular feed circuit influenced by the switch is in open position and will not, therefore, be included in the automatic operation which is being performed.

Automatic operation with manual selection of number of suds and rinsing operations, respectively

In the commercial use of this form of the invention it may in some instances be desirable to eliminate the analysis operation performed by the photo-cell mechanisms which determine the number of suds and rinse operations, respectively, and in place thereof to manually pre-select the number of suds operations which will be automatically performed by the apparatus and the number of rinse operations which will follow.

In order to provide for this alternative type of operation, certain additional features of this mechanism have been included and will now be described.

Manual pre-selector

Reference to Fig. 16 will show that there is provided a mechanism 920 which will be hereinafter referred to as the washing manual pre-selector. This mechanism is of the general construction represented in Figs. 21 to 23, inclusive, and will serve to permit the operator to pre-select any desired number of suds operations and, when once set, will cause the selected number of suds operations to occur automatically.

By referring to Fig. 21, it will be noted that the washing manual pre-selector comprises a dial 921 which is mounted in an accessible place, as, for

instance, on the front panel of a box or housing in which the control mechanism may be mounted, and which may be subdivided into any desired number of "stop" positions such as, for instance, the twelve stop positions noted in Fig. 21.

In addition, a manually operable knob 922 is provided which is fixed to a shaft 923 which is adapted to move a cam, as hereinafter described. The knob 922 is provided with a pointer 924 which will clearly indicate at all times the position of the shaft with respect to zero position. The shaft 923 is preferably provided with a flat side whereby the cam disc 925, illustrated in Fig. 23, may be fixed thereto. The shaft may be supported on a suitable support 926 by means of an upstanding member 927, whereby rotary movement of the shaft 923 is permitted under the control of the manually operable knob 922, with a corresponding movement of the cam disc 925.

When the pointer 924 of the manually operable knob is on zero position, as shown in Fig. 21, the cam groove 928 is in a position to receive the V-shaped end portion 929 of the spring contact arm 930. Spring contact arm is provided with an electrical contact member 931 which is adapted to make contact with the contact member 932 carried by the other contact arm 933. The two contact arms 930 and 933, respectively, may be mounted between suitable insulating members 934 which are held on the support 935 in any suitable manner. The contact arms 930 and 933 have their upper ends exposed for suitable connection with wires, whereby the switch so provided is connected in the control circuit in a manner hereinafter described.

As shown in Fig. 22, there is also fixed to the shaft 923 a ratchet wheel 936, preferably having a number of teeth corresponding to the "stop" positions indicated on the dial 921. This ratchet wheel has associated therewith a spring pressed pawl 937 which affords some resistance to movement of the ratchet in the various "stop" positions, so as to indicate to the operator the position of the shaft 923 and, accordingly, the cam disc 925 corresponding to any predetermined "stop" position as shown on the dial. The pawl member 937 may be pivoted as at 938 and may be provided with a spring pressing device, such as a spring 939, supported from a frame part 940.

Associated with the ratchet 936 is a solenoid-operated pawl mechanism which serves to move the ratchet one tooth for each solenoid impulse in a counter-clockwise direction, as shown in Fig. 22. This mechanism comprises a yoke 941 which is preferably pivoted on the shaft 923 in a manner to be rotatable independently thereof. This yoke 941 terminates in an extended lever arm which is adapted to rest on a stop member 942 which is adjustable, as shown, so as to limit the downward movement of the yoke. The yoke is also connected with a tension spring 943 which serves to return the yoke to the lowermost position, as shown in Fig. 22. The yoke also carries a suitable pivot pin 944 which serves as a pivot mounting for a pawl 945 which is so constructed and positioned as to engage the teeth, respectively, of the ratchet for counter-clockwise movement thereof when the yoke is lifted.

Associated with the pawl is a stationary pin 946 carried by the frame and on which the underside of the pawl rides. Due to this pin, the pawl will be lifted when it is in retracted position so as to move the end thereof outside of the circumferential path of movement of the ratchet teeth. The pawl, however, is constructed with a recess

947 whereby the advancing movement of the pawl will cause the same to drop downwardly on the pin 946 in such manner as to present the end thereof for engagement with the face of the adjacent tooth, whereby to cause the same to impart a counter-clockwise movement to the ratchet.

It will further be noted that the pawl 945 is provided with a spring 951 for at all times urging the pawl into operative position. The lifting of the pawl outside of the maximum diameter of the ratchet is for the purpose of permitting the ratchet to be moved in a clockwise direction under the control of the manually operable knob 922.

The upward movement of the yoke 941 is effected by means of a solenoid mechanism, referred to generally as 948, which is equipped with a plunger 949 which connects through a link 950 with the yoke 941 in any suitable manner.

It will be apparent from the drawings that the above described construction permits the cam 925 and ratchet 936 to be moved to any desired position by the manual setting of knob 922. Hence, prior to starting the washing operation, the operator is free to give the dial shown in Fig. 21 any preselected position, with the result that the recess 928 on the periphery of the cam disc 925 will occupy a position removed from the zero position by the space of the number of teeth represented by the selected number on the dial.

It will also be apparent that when the solenoid is energized, the ratchet mechanism will be effective to move the ratchet one tooth in a counter-clockwise direction, with the result that the cam recess 928 will be correspondingly moved the angular distance represented by one tooth space of the ratchet. Accordingly, it will be necessary to energize the solenoid successively a number of times, equal to the selected number on the dial, to restore the recess 928 to its original zero position.

It is possible with this construction to effect the original manual pre-selection by a movement of the knob 922 either in a clockwise or in a counter-clockwise direction from zero position, as may be desired by the operator, as in either case the pawl 937 will permit the necessary movement and the final position is the same irrespective of how it was reached.

With this understanding of the mechanism 920, the manner of connecting it into the automatic circuit will now be described. It will be noted from Fig. 16 that the solenoid and mechanism 920 are diagrammatically represented and that the solenoid is identified as 948.

In order to cause the control mechanism to function under the control of the wash manual pre-selector, it is only necessary to move the manually operable switch 680, shown in the lower left-hand portion of Fig. 16A, from full-line position as shown in the drawing to the dotted-line position. The immediate effect of this switch movement is to cause a connection between line 679 and line 952. It will be noted from Fig. 16 that line 952 connects directly with the solenoid 948 of the washer manual pre-selector and also connects through line 953 with one of the contacts of the cam operated switch shown in Fig. 23. In this description, this contact switch is designated 925 in Fig. 16, which is the same numeral used for the cam disc in Fig. 23.

As previously described in connection with the full automatic operation, line 679 constituted a part of the circuit which was energized by the relay switch 677 of the relay 675 and served to connect the photo-cell 670 in a circuit which in-

cluded the solenoid 671 of the multiple coil relay 672, shown at the left-hand side of Fig. 16. In other words, line 679 was a part of the circuit which was connected during the washing operation by the closing of contact switch 668 of the washer cam set and which would be energized to close relay switch 689 if the photo-cell operated to that end. However, by the movement of the manual switch 680, as above indicated, the washer manual pre-selector has been connected in the circuit for energizing the coil 671 of the relay 672 in place of the photo-cell mechanism 670, and hence the movement of the relay switch 689 is under the direct control of the washer manual pre-selector.

The result of this new circuit will be more clearly understood by describing its operation, for the purpose of which it will be assumed that the knob of the pre-selector is moved initially to the point marked "2." This selection will be made when the operator desires two suds operations to occur automatically, after which the control mechanism will be automatically shifted to the rinsing control mechanism.

When the pointer 924 is moved to the point marked "2" on the dial, the recess 928 of the cam disc 925 is moved to a corresponding angular position away from the top zero position. With the parts thus disposed and with the manually operable switch 680 in the dotted-line position, it will be apparent that the movement of the washer cam set during the first suds operation through approximately $247\frac{1}{2}$ degrees of movement from zero position will cause the contact switch 668 to be energized. This will cause the relay coil 674 to be energized and the relay switch 677 to be closed. The closing of relay switch 677 then causes current to pass into line 679 through switch 680 into line 952, and thence into the solenoid 948 of the washer manual pre-selector. Inasmuch as the solenoid 948 has its other side connected through line 954 with the line 564 which extends to the other current line 517, the solenoid will be impulsed whereby the ratchet 936 will be moved one tooth space in the counter-clockwise direction. As a result, the pointer will be moved from the original set position marked "2" back to the position marked "1," where it will come to rest.

Under the automatic control of the washer cam, a second suds operation is initiated in the manner previously described, with the result that during the subsequent suds treatment contact switch 668 is again connected, with a duplication of the operation just described. As a result, solenoid 948 again receives one impulse and again acts to move the ratchet one tooth space in a counter-clockwise direction and pointer 924 of the washer manual pre-selector is thus moved to zero position.

As previously explained, this counter-clockwise movement also moves the cam disc 925 in a counter-clockwise direction and thereby restores the recess 928 to its original zero position, whereby the V-shaped end 929 of the contact arm 930 is free to move downwardly under its inherent spring tension so as to establish contact between the contact points 931 and 932.

The closing of this contact switch is represented diagrammatically as a connection at 925 in Fig. 16. The final result is that current passes through the contact switch shown diagrammatically in Fig. 16 as 925, into line 955, which, as shown on the drawing, connects with line 688 which as previously described connects with the lower relay coil 671 of the multiple coil relay 672.

In this manner, the relay switch 689 is shifted from the full-line position shown in Fig. 16 to the dotted-line position, whereby a circuit is conditioned which will later be employed to energize the coil 690 of the multiple coil relay 691.

This last operation, however, occurs at the same time as that previously described in connection with the full automatic operation of the device. In other words, the closing of relay switch 689 serves to condition a circuit which is finally closed when contact switch 546 of the washer cam set is closed, which occurs when the washer cam set is in its final position. In consequence, the multiple coil relay 691 is caused to be shifted from the full-line position to the dotted-line position to cause the current to be connected to the rinse control mechanism and disconnected from the washer control mechanism.

From the foregoing, it will be apparent that the washer manual pre-selector may thus be employed to give any desired number of suds operations that may be pre-selected, in place of the number which would be determined by the analyzing action of the photo-cell mechanism 670.

Rinse manual pre-selector

As shown in Fig. 16, a rinse manual pre-selector 960 is provided having a solenoid 961. Insofar as the mechanical construction is concerned, this mechanism may be the same as that shown in Figs. 21 to 23, inclusive, in connection with the wash manual pre-selector.

In order to connect the rinse manual pre-selector in operation, it is only necessary to move the manual switch 786, shown at the bottom left-hand side of Fig. 16A, from full-line position to the dotted-line position. This acts to connect line 785 with line 962. It will be noted from Fig. 16 that line 962 connects directly with the solenoid 961 and also through line 963 with the rinse manual pre-selector 960. The other side of the solenoid 961 connects through line 763 with the other current line 517, and the other side of the rinse manual pre-selector contact switch 760 connects through line 964 with line 794.

The circuit thus established serves to connect the rinse manual pre-selector in the circuit for energizing coil 777 of the multiple relay 778 in place of the photo-cell mechanism 776 in exactly the same manner as previously described in connection with the substitution of the wash manual pre-selector for its photo-cell 670. Furthermore, it is apparent that the result will be the same, namely, that the rinse manual pre-selector will function in this new circuit to give any desired number of rinsing operations according to the pre-selected setting chosen by the operator.

It is further apparent that the automatic rinsing operation is otherwise the same as that accomplished when the full automatic mechanism is functioning, and that the shift over from rinse control to blue and sour control cam set will be in all respects the same as that of the full automatic operation.

Attention is called to the fact, however, that the manually operable switches 680 and 786 are capable of separate and independent movement, whereby it is possible to connect the wash manual pre-selector for operation with the automatic control while leaving the rinse photo-cell mechanism in connection for operation during the rinsing operation. Conversely, it is possible to connect the rinsing manual pre-selector for operation while leaving the photo-cell mechanism in control of the number of suds operations, and

thus any desired combination of these possible operations may be realized. Accordingly, the machine may be operated on full automatic, that is to say, with both washing and rinsing photo-cell mechanisms connected, or it may be operated with both manual pre-selectors in control or with any one of the pre-selectors in conjunction with the other automatic control. In this way, four possible combinations of operation are possible.

It is to be further understood that this invention contemplates a device equipped with the photo-cell mechanism without, however, having the wash and rinse manual pre-selectors embodied therein, and also a mechanism which operates entirely through the use of the manual wash and rinse pre-selectors without the photo-cell mechanism incorporated therein.

Manual switch operation

In addition to the foregoing, this modification of the present invention is capable of operation by the use of what may be termed "manually operated electric controls." This form of operation permits the automatic control mechanism to be disconnected altogether while at the same time providing a series of independent circuits adapted to cause the dump valve to open and close, the water to be turned on and off, the thermal control mechanism to be connected and disconnected, and finally the washing machine motor to be started and stopped. With this type of operation, all materials to be added to the washing machine may be introduced by hand through the soap door normally provided on the washing machine, in accordance with practice which is now well understood in the art.

To operate the machine in this manner, the manually operable, double throw switch 513 is shifted from the full-line position to the dotted-line position, as shown in Fig. 16. This serves to connect the main current lines 511 and 512, respectively, with lines 970 and 971, and to disconnect the current from the current lines 514 and 515, respectively, which extend to the automatic control mechanism. It will be noted from Fig. 16A that line 971 constitutes a bus-bar which connects with the double throw switch 520 through line 972 to the switch 630, and thence through line 973, to switch 744, and on to line 974, and one of the terminals of switch 599. On the other hand, line 970 extends up to one of the terminals of the double throw manual switch 520 so as to supply the other current line connection in place of line 517.

Manual start of motor

It will thus be seen that when the manually operable, double throw switch 520 is moved to dotted-line position, a direct current connection is established through lines 521 and 522 for the control of the motor in exactly the same manner that current was fed thereto through the current connections for the automatic apparatus. Thus, it will be seen that the motor may be started and stopped through the manual operation of the double throw switch 520.

Manual operation of dump valve

It will further be apparent that through the movement of the switch 620 to the dotted-line position, the dump valve may be opened or closed.

Manual control of water valve

Similarly, by moving manually operable switch 744 to the dotted line position shown in Fig. 16A,

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it is apparent that the water valve may be opened so as to feed water into the washing machine.

Manual connection of thermal control unit

Finally, by moving the manually operable switch 599 to the dotted-line position, the thermal control mechanism is energized directly whereby the water fed into the washing machine may be automatically controlled as to temperature.

The connection of these mechanisms as described depends entirely upon the manual switches referred to and, consequently, to disconnect them it is only necessary to manually move the switches to open position.

It will be noted that all of the switches 520, 630, 744 and 599 have three possible positions, one of which is for automatic operation, another of which is for manual connection, and the third of which is open with respect to both of these types of control. With the manually operable switches referred to, any desired manner of performing the washing operations may be practiced according to the dictates of the individual operator.

MODIFICATION SHOWN IN FIG. 25 AND FIG. 26

FIRST MODIFIED TIMING MECHANISM

It has been found in practice that the washing procedure established by the control mechanism heretofore described is satisfactory in those instances where the particular timing periods provided for the suds, rinsing and other operations fits the circumstances met with. However, when the control mechanism is applied to various different types of washers which for mechanical or other reasons may vary to some extent in washing efficiency, it is found that different suds, rinsing, and other periods may be preferred. Furthermore, in certain instances with the same washing mechanism, water and other conditions may vary to an extent which will make it preferable to utilize different timing periods. For instance, hard water results in a less efficient washing operation than when soft water is used with all other conditions the same.

For these reasons, modified timing mechanisms have been devised as parts of this invention, whereby different timing periods may be selected by the operator according to his preference in any particular case.

One modified timing mechanism is illustrated in Fig. 25, and insofar as the parts thereof correspond to the parts shown in Fig. 16, the same reference numerals have been employed. In addition, the wiring connections have been given the same numbers whereby the relationship of the modified timing mechanism to the other parts of the control circuits may be readily ascertained.

The fundamental difference between this timing mechanism and that shown in Fig. 16 is that instead of having one timing cam 552, four such timing cams are provided which are designated 552—A to 552—D, inclusive. Similarly, four cams 702—A to 702—D, inclusive, are provided instead of the single cam 702 shown in Fig. 16. Furthermore, three cams 816—A to 816—C, inclusive, are provided instead of the single cam 816. It is contemplated that any desired number of cams of each set may be provided, and the invention is not to be limited to the number here shown.

All of these cams are mounted for simultaneous rotation on the single shaft driven by the

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timing motor 562 which is connected to a source of current by the current lines 561 and 563, respectively, in the same manner illustrated in Fig. 16.

All of the cams 552—A to 552—C, inclusive, are connected in parallel, as shown in the drawing, to the line 553 on one side thereof and to line 551 on the other side thereof through the instrumentality of a manually operable switch 1401 which may be moved by the operator so as to bring any one of the four cams into operation to the exclusion of the other three.

In a similar manner, the four cams 702—A to 702—D, inclusive, are connected in parallel between lines 703 and 701. The line 701 has associated with it a manually operable switch 1402 by which any one of the parallel-connected cams can be employed to the exclusion of the other three.

Similarly, the cams 816—A, 816—B and 816—C are connected in parallel between the lines 805 and 815, and in this arrangement a manually operable switch 1403 is employed by which any one of the cams may be connected for operation to the exclusion of the other two.

From the foregoing, it will be apparent that various timing periods may be provided on each of the cams and that through the proper adjustment of the manually operable switches 1401, 1402 and 1403, respectively, any desired combination of timing relations may be established for giving the desired washing operation.

SECOND MODIFIED TIMER

A second modification is illustrated in Fig. 26, which also provides the desired variation in timing periods.

In this case, however, three separate variable speed motors are employed, respectively, for each of the cams 552, 702 and 816 instead of utilizing a plurality of cams operating at the same speed. As shown in the drawing, cam 552 is driven by a motor 562—A which is equipped with a manually adjustable speed variator 1405—A. This motor is connected to the current lines 561 and 563 through lines 561—A and 563—A, respectively. By manually adjusting the speed variator 1405 to give any desired speed, any desired speed may be given to the cam 552 so as to establish a timing period of any desired duration.

Similarly, cam 702 is driven by a variable speed motor 562—B having a manually adjustable speed variator 1405—B. This motor is connected by lines 561—B and 563—B to the current lines 561 and 563, respectively.

Finally, cam 816 is driven by a variable speed motor 562—C having a manually adjustable speed variator 1405—C. This motor is connected through lines 561—C and 563—C to the current lines 561 and 563, respectively.

It will be observed that by these modifications any desired timing may be secured in the washing, rinsing and other cycles provided by the control mechanism illustrated in Figs. 16, 16A and 16B.

It is to be understood that similar modifications may be employed in the control mechanism illustrated in Figs. 1, 1A and 1B, and that when such modified timing mechanism is employed, any desired variation may be had in the timing periods, either by similarly varying all of the timing periods in any one operation, or by varying the particular different periods in any particular operation.

SUMMARY OF OPERATION—SECOND FORM

After the articles to be cleaned have been placed in the washing machine in the usual manner, the starting switch is manually moved to "on" position, with the result that the motor which rotates the washing machine cylinder starts to operate. In addition, current passes into the main current lines, with the result that the solenoid of the washer cam set is immediately energized and the washer cam set is moved one position and stops. The washer cam set stops because its movement is caused by a circuit which includes, in addition to the timer switch, a switch controlled by the cam set itself, and when the cam set moves this circuit is broken.

As already stated, the circuit for energizing the washer cam set solenoid includes the timer, and if the timer should be at rest with the timer cam located at "off" position this would not interfere with the starting of the washer cam set because the "at rest" position of the washer cam set permits current to pass to the timer motor, with the result that if the timer is not already on "on" position as above supposed, it immediately will be moved to "on" position, whereby the desired result will come to pass. The consequence of this action is that the washer cam set has its series of contacts connected to the main power line, and after being moved one segment it is brought to rest.

By movement to the first position, the following events occur:

1. The dump valve is closed;
2. Water is fed to the washing machine;
3. The thermal control mechanism regulates the temperature of the water;
4. The soap feeding circuit is conditioned;
5. The circuit for operating the timer is conditioned; and
6. The alkali feeding circuit is conditioned (provided alkali is not fed in and mixed with the soap).

With the controls thus established, water at the desired temperature flows into the washing machine until the level reaches the lower level control switch, at which time the switch is thrown, which acts to—

1. Cut off the water feed; and
2. Start the feeding of soap.

The soap thus introduced starts to form suds and the soap feed is continued until the suds level reaches the level of the intermediate diaphragm switch. When the soap level reaches this height, the intermediate switch is thrown, which acts to—

1. Stop the soap feed; and
2. Connect the circuit to the timer motor.

At the same time the soap is fed, a separate circuit may be connected in a similar manner to feed a predetermined quantity of alkali, or, if desired, the alkali may be admixed with the soap in proper proportions so that the soap and alkali are introduced together.

In any event, when the feeding of the soap is completed, the timer motor starts to operate and the suds treatment is started under the timed control of the washer cam set. During the suds treatment a small flow of the washing liquid is continuously drawn from the lower portion of the washer and passed through a pipe which includes a glass or other transparent section.

After the suds treatment has been carried out

for the prescribed period, connections are made which energize a photo-electric cell adjacent the pipe referred to and also the electric lamp associated therewith. The photo-electric cell so connected is capable, upon receiving a certain quantity of light thereon, as, for instance, the light projected through a transparent section of the pipe when and if the washing liquid passing therethrough is of sufficient clarity, of conditioning a circuit for throwing the current switch, which, when later thrown, will disconnect the washer cam set altogether and connect in its stead the rinse cam set for continuing the treatment.

However, before the washer cam set completes one revolution, the previously established timer motor circuit, which includes the diaphragm mechanism, is disconnected and a second and more direct timer motor circuit is established, and the circuits which energized the photo-electric cells and associated lamps are broken. If during the period when the photo-electric mechanism is energized the washing liquid passing through the associated pipe is sufficiently clear for the passage of the requisite amount of light, then a circuit for throwing the current switch will be conditioned and upon completion of rotation of the washer cam set the current line is disconnected from the washer cam set altogether and is connected to the rinse cam set.

When this occurs, the operation is continued under the controlled action of the rinse cam set, without interruption. On the other hand, when the washing liquid is not sufficiently clear to permit the passage of the amount of light requisite to condition the circuit as above indicated, then the current switch throwing circuit is not conditioned and nothing occurs when the washer cam set reaches its last segmental position, but rather its rotation continues and the above-described suds operation is duplicated.

During each suds operation, however, the photo-electric cell mechanism is energized, and when the clothes being washed are sufficiently clean to permit the washing liquid to remain sufficiently clear to pass that amount of light necessary to condition the switch-throwing circuit, the washing treatments are discontinued at the end of that particular suds and the operation passes on to the prescribed rinsing treatments.

At the end of each suds treatment, the dump valve is opened and the direct timer motor circuit is broken. The other circuit for the timer motor, which includes the diaphragm mechanism, is conditioned at the outset when the suds treatment is commenced.

After the operation has shifted to the rinsing treatment, the connection of the current causes the rinse cam set to move one segment and come to a stop. This operation is the same as that previously described in connection with the washer cam set, and here as there, if the timer switch is in "off" position, the timer motor is momentarily connected so as to move the timer to "on" position to bring about the desired result.

When the rinse cam set has been brought to the first segmental position the following events occur:

1. The dump valve is closed.
2. Water is fed into the washer under the control of a circuit which includes the highest of the three diaphragm switches;
3. The thermal control mechanism regulates the temperature of the water; and
4. A circuit for the timing motor, which in-

cludes the highest diaphragm switch, is conditioned.

With the conditions thus established, water at the desired temperature flows into the washer and continues to flow until the level thereof is sufficient to operate the highest of the three diaphragm switches. When the proper amount of water is introduced, the highest diaphragm switch is actuated, the water feed is turned off, and the timing motor is started. The clothes are thus rinsed under the controlled movement of the rinse cam set.

During the rinsing treatment, a second photo-electric mechanism, which includes a photo-electric cell and associated lamp disposed adjacent a transparent section of the pipe previously referred to, is energized, and here again, when the rinsing liquid is of sufficient clarity, enough light will pass through the transparent section of the pipe to cause the photo-electric cell to condition a circuit for throwing the current line from the rinsing cam set to the sour and blue cam set.

Furthermore, during each rinsing treatment a new and direct timing motor circuit is established and the previously described timing motor circuit, which includes the diaphragm mechanism, is disconnected. In addition, at the end of each rinsing treatment means are provided on the cam set for causing the dump valve to open. Also, the rinse cam set includes, at its end segment, means for completing the circuit for throwing the current switch when and if the same has been conditioned by the photo-electric mechanism previously referred to.

In addition to the foregoing, means are provided for causing a prescribed amount of bleach to be introduced into the washer during the first rinse treatment. The control is arranged so that only one charge of bleach will be introduced even though succeeding rinsing treatments are called for by the control mechanism.

The mechanism thus described will operate to produce required rinsing operations, and during each will, through the action of the photo-electric mechanism, determine whether or not the rinsing is completed by testing, during each rinse, the clarity of the rinsing liquid. If the rinsing is not complete according to this detection, the rinsing operation is repeated and a second inspection made during the second rinsing treatment, and so on.

At the time when the rinsing is complete, however, as evidenced by a predetermined degree of clarity of the rinsing liquid, then the current throwing switch circuit is conditioned, and upon the completion of that particular rinsing treatment the current is disconnected from the rinse cam set and connected to the blue and sour cam set which controls the next steps of the operation.

When the current switch is moved to connect the blue and sour cam set, this cam set is already in its first segmental position. This is effected by a movement of the blue and sour cam set as caused by a special circuit which is set up by the rinse photo-electric cell mechanism and by which such movement occurs at the time the current switch throwing circuit is conditioned during the rinsing treatment. Immediately upon connecting the blue and sour cam set the following events occur:

1. The dump valve is closed; and
2. Cold water is turned on under the control of a circuit including the highest diaphragm switch.

With the conditions thus established, water

flows into the washer until it is cut off by the highest diaphragm switch.

When the water is turned off, the timing motor circuit, under the control of this highest diaphragm switch, is completed and the timer starts to operate the blue and sour cam set. At the same time that this occurs, a predetermined quantity of blue is discharged into the washer, whereby the blue treatment for the prescribed period is carried out.

Before the blue treatment is terminated, a direct timer motor circuit is established and the previously established timer motor circuit, which includes the highest diaphragm switch, is disconnected. After the blue treatment has been conducted for the prescribed period, the dump valve is opened. During the dumping operation, the direct timer circuit continues the movement of the cam set, and thereupon the dump valve is again brought to closed position and the sour treatment started.

After the closing of the dump valve, water is fed in, and on this occasion the water control circuit includes the diaphragm switch which is much lower than that previously employed for controlling the height of the water. This permits a much smaller volume of water and consequently enables a reasonably concentrated sour treatment without requiring an excessive quantity of sour.

When the level of the water has reached the diaphragm switch in question, the water feed shuts off and immediately the timer starts operating under the control of a circuit which includes this diaphragm switch. At the same time, a predetermined quantity of sour is introduced into the washer, and thence the sour treatment is conducted for the prescribed period.

After the sour treatment has been conducted for the necessary time interval, the blue and sour cam set comes to its final position, where numerous resetting solenoids are energized to reset various switches which have not already been reset during the course of operation. In consequence, when the blue and sour cam set comes to its final position, the entire control mechanism is brought to rest, the washing machine motor is stopped, and all parts of the control mechanism are restored to their original positions.

The mechanism also enables the operator to manually operate the various chemical feeds, as well as the feed and control for the water supply and the dump valve. This is done by manual switches which not only serve to disconnect the automatic mechanism but serve to positively actuate the devices with which they are connected.

In addition, semi-automatic washer and rinse mechanisms are provided, which include dial mechanism capable of being manually set to any desired number of suds operations and/or rinse operations, with the result that the mechanism will automatically produce the selected number of suds and/or rinse operations in lieu of the number of each that would be automatically determined by the operation of the photo-electric cell mechanisms.

THIRD FORM

[Figure 24]

Reference will now be made to the third illustrative form of this invention, which will be more particularly understood by the disclosure in Fig. 24.

WASHING MACHINE CONSTRUCTION

The control mechanism here illustrated is adapted for use in connection with a washing machine which may be of any suitable construction, provided, however, that it is equipped with a discharge outlet for the washing liquid through which the liquid may pass at substantially the same rate at which it is introduced. In other words, the control mechanism here referred to is characterized as being applicable to what may be regarded as a continuous liquid flow type of washing machine or one in which washing liquid is discharged from the washing machine continuously during the suds operation at substantially the same rate that the washing liquid is introduced therein. A second characteristic is that the washing machine should be provided with a second discharge, positioned above the first-mentioned discharge, through which suds may pass in a manner and for a purpose hereinafter described.

Machine proper

Although the washing machine may be of any suitable construction provided it has the above-described features, it is here illustrated as comprising a stationary, horizontally disposed housing 1000 having therein a rotary cylindrical clothes-container 1001. The washing machine is represented only diagrammatically in the drawing as this general construction is well understood in this art. It should be noted, however, that the particular form here illustrated includes a plurality of ribs 1002 mounted on the inside of the rotary cylinder 1001, which may be of conventional construction.

The rotary cylinder itself is preferably provided with a series of openings so that the water from the main washer 1000 may pass into the interior thereof and, whereas these may be of any general construction, in the present form they are provided as a series of longitudinal slots or louvers represented diagrammatically 1003. These louvers are so disposed as to permit the washing liquid, which is fed into the interior of the washing machine through a pipe 1004, to pass therethrough when the same is projected in a generally upward direction as represented by the lines 1005. In other words, the form here shown contemplates the use of an upwardly projected spray of washing liquid which is adapted to pass through the louvers 1003 directly into the interior of the rotary washing cylinder.

Machine driving motor

The washing cylinder is adapted to be driven by a suitable motor 1006 which may impart a unidirectional or a reversing rotary movement to the washing cylinder as may be desired. For the purpose of this illustration, however, it may be considered that the washing cylinder is driven in a unidirectional manner, as indicated by the arrow, or, in other words, in a counter-clockwise direction as shown in the drawing.

Supports and doors

The washing machine is supported on suitable legs, not shown, and may also include doors of any suitable construction whereby the operator may have access to the interior of the washing cylinder. By way of illustration, such doors are shown at 1007 in the outer cylinder and 1008 in the inner rotary cylinder.

Dump valve

At the base of the washing machine a dump valve 1009 is provided which may be controlled through a lever 1010 which is operated by fluid pressure introduced in the piston and cylinder 1011. The fluid pressure for operating the piston within the cylinder 1011 may be controlled by solenoid-operated valves 1012 and 1013, respectively. This dump valve mechanism may be of any suitable construction and, by way of example, may be of the construction illustrated in Figs. 3 and 4.

Washing liquid discharge pipe

Adjacent the dump valve an exit pipe or duct 1014 is provided which preferably extends circumferentially upwardly from the base of the washing machine to a more elevated position, such as, for instance, the position shown in Fig. 24. The elevation of the upper end of the discharge duct 1014 should be selected as that of the height of the liquid bath to be normally maintained in the washing machine during the washing operation. The amount of liquid so maintained may vary according to the requirements in each particular case, and consequently the invention is not to be restricted to any particular height of the discharge duct.

From the elevated position, the discharge duct preferably extends downwardly or in such direction as to permit the discharge liquid to flow therethrough, and is equipped with transparent sections 1015 and 1016 which are adapted to permit the transmission of light for a purpose hereinafter described. It is preferable to have two separate transparent sections, although one section for accommodating two light-responsive means could be employed if desired. The discharge duct 1014 is intended to discharge the washing liquid into a sewer or other waste outlet, but in so doing it should be devised to always maintain a column of the discharged liquid in the section of the discharge duct where the transparent sections 1015 and 1016 are located. This may be done by any suitable means, such as by placing the transparent sections in a U-shaped portion of the discharge duct or by the use of a discharge trap or by any other means which will accomplish this result.

Suds discharge pipe

Located above the uppermost portion of the discharge duct 1014 is a second discharge duct 1017 which is provided with a transparent section 1018 and which in other respects is similar to the discharge duct 1014, except that it is not essential, in connection with this duct 1017, to maintain the liquid column, as heretofore described.

Water supply

The washing liquid, which in this case is water, may be supplied to the washing machine through hot and cold water supply pipes 1019 and 1020, respectively, which feed into a cylinder 1021 containing a piston which may be of the same construction shown in Fig. 1B.

Thermal control mechanism

This thermal control mechanism is equipped with two solenoid-operated valves designated 1022 and 1023, respectively, which control the fluid pressure supplied to the ends of the piston mounted in the cylinder 1021. These valves will function to feed the desired mixture of hot and cold water in a manner similar to that described

in connection with the other modifications, or, in other words, by means of a relay 1024 which is controlled by a thermostat mechanism 1025 connected to the water inlet pipe 1026. One characteristic of this control mechanism is that when the thermostat 1025 is deenergized the relay occupies the position illustrated in the drawing, whereby the solenoid of the upper valve 1023 is energized so that only cold water is fed into the washing machine.

Water inlet

The water inlet pipe 1026 contains a main control valve 1027 which may be of the same construction as that illustrated in Fig. 6, that is to say, it may be equipped with a fluid-operated piston mounted in the cylinder 1028 and be provided with solenoid-controlled valves 1029 and 1030 in association therewith.

Supply of agents

This control mechanism also includes sources of supply of various agents such as soap, alkali, bleach, blue and sour, which will hereinafter be described, and all of which are fed into feed pipe 1031 which extends into the water pipe 1026 and terminates therein in the form of an injector nozzle or jet, whereby the agents fed to the pipe 1031 by gravity are introduced into the washing machine by an injector action created in the water pipe 1026.

Timing mechanism and photo-cells

The control mechanism also includes a timing device which comprises a plurality of cams which are fixed to rotate with the timer shaft 1032, and in addition three photo-electric control devices, the nature and operation of which will be later pointed out in connection with the detailed description of the illustrative embodiment shown in Fig. 24.

CONTROL MECHANISM

Main current lines

Referring now to Fig. 24, the main current lines are shown at the top as lines 1035, 1036 and 1037, respectively. For the purpose of shutting off the current at night or, in other words, for completely disconnecting the mechanism from the current source, a manual multiple switch, designated 1038, may be provided.

For the purpose of connecting the motor and also connecting the control mechanism, a magnetically operated switch 1039 is provided which comprises three switch elements 1400 which connect the three main current lines, respectively, with lines 1040, 1041 and 1042 which serve to supply current to the operating motor 1006. This magnetically operated switch has a coil 1043 and a core element 1044 and a fourth switch element 1045. It will be noted that all of the switch elements are connected for operation by the core.

Manual starting switch and associated circuits

In addition to the foregoing, a manually operable switch 1046 is provided which in this instance is shown as a spring-backed contact member which will close a circuit when it is pushed inwardly but which will immediately move outwardly when released to break the contact so made.

This switch 1046 is provided with one contact 1047 which connects through line 1048 with the main current line 1036. The other contact thereof 1049 connects through line 1050 with one end of the switch element 1045 and also through line

1051 with one end of the coil 1043. The other end of the coil 1043 connects through line 1052 with the other current line 1037. The current line 1048 has connected thereto a line 1053 which, as shown in the drawing, extends downwardly and connects with the contact member 1054 of the timer control switch 1055. The other side of this switch connects through lines 1056 and 1063 with the contact element 1057 of the magnetically operated switch 1039 previously described. It will be noted that the contact element 1057 just referred to is disposed for cooperation with the switch element 1045 previously described.

Timing device

It should be understood at this point that the timing mechanism shown in the lower right-hand corner of Fig. 24 is brought to rest at the completion of each particular operation, with the cam parts disposed in substantially the positions shown in the drawing, from which it will be understood that only one switch, namely, that shown at the extreme left, is closed. It should be further understood that the timing device illustrated, when in operation, is adapted to be moved by a step-by-step motion through the instrumentality of a solenoid-operated ratchet mechanism referred to generally as 1058, which may be of a construction substantially similar to that shown in Fig. 11 in connection with the first modified form of this invention. Furthermore, the solenoid 1059 for operating the mechanism is adapted to be impulsed during certain stages of the operation of this mechanism by a timer cam 1060 which is adapted to make and break contact in a manner similar to that previously described, and which is adapted to be run by a motor 1061 for giving a uniform rotation to the timing cam.

Starting washing operation

In order to start a washing operation, the washing machine is filled with the desired quantity of clothes in the usual manner, and after the doors thereof are closed, it is only necessary for the operator to push the starting button 1062 of the switch 1046. This starting button serves to close the circuit between contacts 1047 and 1049, whereby current flows through the coil 1043 and causes a left-hand movement of the switch core 1044. This immediately moves the three switch elements 1400 which connect the motor 1006 with the main current lines, whereby the motor starts to operate. In addition, however, switch 1045 is brought in contact with contact element 1057 whereby current is free to pass from line 1051 through the switch element 1045 and into current line 1063.

Referring now to the bottom of Fig. 24, it will be noted that the current is free to pass from line 1063 into line 1064 through the switch element 1065 which, as previously described, is in closed position, and into line 1066 which connects directly with the timing cam 1060.

Position of timing cam upon starting

At the moment this occurs, the timing cam is stationary, but in such position as to close the contact therethrough by virtue of the fact that it was previously brought to rest in such contact position. This will be apparent when it is realized that the contact of the timer cam referred to was depended upon to energize the solenoid 1059 of the timer mechanism at the completion of the last run for moving the parts to that position which stopped the entire mechanism, with the result that the timer cam itself was also stopped

at the moment the contact referred to was closed. This manner of operation assures that the timer will be in closed contact position at the commencement of each successive run.

Initial movement of timing mechanism

Accordingly, current from line 1066 passes through the timer 1060, through line 1067 and into the solenoid 1059. By virtue of the fact that the other side of the solenoid 1059 is connected to the other current line, it will be apparent that the solenoid receives an impulse which moves the timing mechanism through an angular distance of one ratchet tooth. The connection between the other side of the solenoid 1059 and the second current line is established by lines 1068 and 1069, the latter of which connects with line 1070. Line 1070, which extends directly upwardly, connects with the other current line 1037.

The angular movement of the timing mechanism one ratchet tooth space as indicated, moves the cams 1071, 1072 and 1073, respectively, to a new position in which each of the switches associated therewith are immediately closed. Furthermore, cam 1074, which initially is two cam tooth spaces from closed position, is moved to within one tooth space of closed position.

Breaking initial solenoid circuit

In addition, the initial movement referred to has caused cam 1075 to move to such position that the switch element 1065 breaks contact with the line 1064 and makes contact with line 1076 for a purpose hereinafter described. By this movement the circuit, which was utilized to energize the solenoid 1059, has been broken, whereby the solenoid returns to its original position. This fact is not altered by the contact which is established between the switch 1065 and the line 1076 because this last-named line is not yet energized.

Main circuits maintained after starting switch is released

By the closing of switch 1055 as above indicated, current from the line 1053 flows into line 1063 previously described and up to the contact 1057 of the magnetically operated switch 1039. It thus flows into switch element 1045 and through the coil 1043 and back to the other current line through line 1052. Thus it occurs that the coil 1043 becomes energized independently of the circuit established by the push-button 1062, whereby the push-button may now be released without disturbing the flow of current to the control mechanism in the manner indicated.

It should be understood that the foregoing occurrences have taken place almost instantaneously and as a result of the initial closing of the push-button switch 1046, and inasmuch as the circuit so established causes the magnetic switch 1039 to be held in closed position without the necessity of maintaining the circuit through the push-button, the push-button may be promptly released without interfering with the operations thus started.

By the closing of the push-button switch 1046 and by means of the subsequently established circuit through the switch 1057, current passes from line 1077 into lines 1078 and 1079 with which the push-button switch 1046 is connected. It will be noted from the drawing that line 1078 connects with the terminal 1080 of the multiple relay 1081 shown on the right-hand side of Fig. 24, and that line 1079 extends down toward the washing cylinder and then connects with line 1082 which

provides a further current line extending to one of the contacts of the relay switch 1081.

Turning on water

At the time the timer was moved the space of one ratchet tooth, switch element 1083 associated with the cam 1073 was caused to engage contact 1084 which is connected with line 1085 which extends up and connects with the two solenoids 1086 and 1087, respectively, associated with the water inlet valve. The other sides of these solenoids are connected to current line 1079 through lines 1088 and 1089, respectively. The other side of switch element 1083 associated with the cam 1073 connects through line 1090 with the other current line 1070.

It will thus be seen that when current is passed into line 1079, as above described, it is free to pass into the solenoids 1086 and 1087 of the water control mechanism and thence downwardly and through the contact 1084 and switch element 1083 and into the other current line through line 1090. Consequently, by the closing of the switch 1083 the water valve 1027 is turned on so as to supply water to the washing machine.

Connection of thermal control unit

At the same time, current passes from current line 1082 into line 1091 and through the switch element 1092 into line 1093 and thence upwardly to the thermostatic control device 1025. The other side of the thermostat connects through line 1094 with one side of the relay coil 1095 of the relay 1024. The other side of this coil connects through line 1096 with the other current line 1070.

At the time the water is originally turned on, the piston in the cylinder 1021 is in such position as to admit cold water, and consequently upon the opening of the water valve, cold water starts to feed into the washing machine. However, by the circuit just described, the thermostatic device 1025 is connected to control the relay coil 1095 whereby the switch element 1097 comes under the direct influence of the relay coil. In consequence, one or the other of the valves 1022 and 1023 is moved to open position, whereby the desired proportions of hot and cold water are supplied to the water inlet pipe 1026 in exactly the same manner as that previously described in connection with the other modifications. In consequence, the starting of the mechanism causes water to be supplied to the washing cylinder at the desired temperature as determined by the setting of the thermostatic mechanism.

Closing dump valve

At the same time that the water is turned on and the thermal control mechanism is connected, contact switch 1098 associated with the cam 1072 is caused to engage the contact element 1099 so as to connect the current in line 1091 with the line 1100. This last-named line connects through line 1101 with the two solenoids 1012 and 1013, respectively, which operate the fluid valves for controlling the dump valve mechanism. As previously described, when the solenoids 1012 and 1013 are energized, the dump valve is closed. The other sides of the solenoids 1012 and 1013 are connected, respectively, through line 1070 with the other current line 1037. In consequence, the dump valve is closed at the same time the water is turned on.

Soap feed

In addition to the foregoing, the current in the dump valve line 1100 also passes into line 1102 which, as shown on the drawing, passes upwardly and connects with the solenoid associated with the soap feed valve 1103 located in the pipe 1104. This pipe extends from a source of soap supply 1105, here diagrammatically represented as a tank having a vent 1106. The other side of the solenoid associated with the valve 1103 connects with line 1107. Line 1107 passes to the right and thence downwardly and terminates in a contact 1108 which constitutes a part of the multiple relay 1081. At this point in the operation, the coil 1109 of relay 1081 is not energized, and consequently the switch elements thereof are in the position represented in full lines in the drawing. In consequence, line 1107 makes contact with the switch element 1110 which in turn connects with line 1111 which extends to one side of the photo-cell mechanism 1112. The other side of the photo-cell mechanism is connected through line 1113 to the other relay switch 1114, which, in this position, makes contact with line 1115 which extends upwardly and over and connects with the other current line 1071.

Alkali feed

In addition, the solenoid associated with the valve 1116 disposed in the alkali feeding pipe 1117 of the alkali tank 1033 is connected in parallel with the soap controlled solenoid by means of a line 1118 which extends from the line 1102 to the solenoid referred to. The other side of the solenoid is connected through a line 1119 to the line 1107 previously described.

It should be observed at this point that the photo-cell mechanism 1112 just referred to is of such construction that current will not flow therethrough until and unless a predetermined quantity of light is being projected thereon. However, at the time the machine is started, light is thrown onto the photo-cell referred to through the transparent section 1018 of the pipe 1017 from the light source 1120 which is connected across the two current lines by means of lines 1121 and 1122, respectively. It thus happens that the photo-cell is actuated by the light (there being no impediment in the pipe 1017 as yet) whereby the current is free to pass therethrough for establishing a circuit from the current line connecting through the dump valve switch 1098 through the soap and alkali solenoids and through the relay 1081 back to the other power line 1115. In consequence, the soap valve 1103 and the alkali valve 1106 are energized, with the result that soap and alkali are free to pass by gravity into the pipe 1031 and out through the injector nozzle located within the water inlet pipe 1026. It is to be understood that the valves 1103 and 1106 are so selected as to size that soap and alkali are fed in the proportions that may be required for establishing the proper detergent effect in the washing machine. Furthermore, the injector nozzle is so constructed as to properly proportion the amount of water to the amount of soap and alkali fed into the washing machine so as to establish the desired detergent and water mixture.

Soap control

With the operation thus started, the water accumulates in the washing machine until the level thereof has reached a sufficient height to flow out

through the discharge duct 1014. At the same time, the soap which has been added produces a suds which rises to a height above the level of the water and eventually partially discharges through the outlet pipe 1017.

When suds are discharged as indicated through pipe 1017, this serves as an indication that a sufficient quantity of soap is present, at least temporarily, and that further feeding of soap and alkali should, at least momentarily, be discontinued.

The present control apparatus effects this operation by virtue of the fact that the discharge of suds through pipe 1017 serves to cut off or impair the passage of light through the transparent section 1018 of the discharge pipe, with the result that the photo-cell mechanism 1112 is temporarily influenced in such manner that current will no longer pass therethrough. In consequence, the circuit which was effective to control the feed of soap and alkali at least is temporarily deenergized, whereby the soap and alkali feeding operations are discontinued. However, as water is continuously flowing into the washing machine, the soap suspension is being constantly diluted and, in addition, soap is being further consumed by the soil in the washing liquid, and therefore the suds level will in all probability be lowered to a level where suds will no longer flow out through the outlet pipe 1017.

Since the discharge pipe 1017 has no means for maintaining a column of suds therein, the discontinuance of the suds flow will permit the pipe to become relatively clear. When this occurs, light from the light source 1120 is again projected onto the photo-cell 1112, with the result that more soap and alkali are introduced into the washing machine.

It will thus be seen that when soap and alkali are present in the washing machine to an extent sufficient to cause the suds to discharge through pipe 1017, the control mechanism operates automatically to cut off the supply of further soap and alkali, and that on the contrary when the soap and alkali are present in insufficient quantity to maintain the suds level above that of the discharge pipe 1017, the control mechanism will operate automatically to introduce additional soap and alkali. In this way, a soap level is maintained within the washing machine at the desired level selected to insure the proper quantity of soap and alkali at all times to perform the desired washing operations.

Under the automatic control thus far described, the apparatus will perform a continuous suds treatment of the clothes throughout an interval of time during which water is being constantly supplied to the washing machine and a similar quantity of water is being constantly withdrawn therefrom and passing outwardly through the discharge duct 1014. In this manner, the clothes receive a thorough and satisfactory washing treatment, which is continued until the clothes are substantially clean. The termination of this suds treatment is determined and effected automatically at the time when the clothes are clean according to predetermined standards for which the machine is adjusted.

Termination of suds treatment

The automatic termination of the suds operation is effected in the following manner: It should be first stated, however, that, when the machine was originally started, current from the line 1093 passed into line 1123 which connects

with the heating element 1124 of the thermostatic time-delay switch 1125. The other side of this heating coil 1124 connects through line 1126 with the other current line 1070. In consequence, so long as the relay switch 1092 is closed the heating element 1124 is energized.

The heating element 1124 is especially constructed for cooperation with the associated bi-metallic switch element 1127 so as to give a delayed circuit closing action as desired for this part of the control mechanism. The heating element, therefore, is designed so as to impart the amount of heat to the bi-metallic element required to move the same to closed position only after a time interval which will assure the presence of a column of dirty water in the transparent sections 1015 and 1016 disposed in the discharge duct 1014. Consequently, after the passing of the required interval of time, the bi-metallic member, which occupies open position when cold, is moved to the dotted line position to make contact with line 1128. This line connects with a second photo-cell mechanism 1129 which has its other side connected through line 1130 with the coil 1109 of the multiple relay switch 1081. It will be noted that the other end of the bi-metallic switch element 1127 is connected directly to the current line 1082, whereas the other side of the relay coil 1109 is connected directly to the other current line 1070.

In addition, the relay 1081 is provided with a switch element 1131 which is also connected to the line 1130 extending from the photo-cell 1129 and is adapted to make contact with the contact element 1132 which is connected to the end of the current line 1082 previously described.

The photo-cell 1129 is so positioned as to receive light passing through the transparent section 1015 from the light source 1133. This light source is connected directly across the two current lines 1121 and 1122 in exactly the same manner as the other light source. The photo-cell 1129 is of such character that current will pass there-through when a predetermined quantity of light from the light source is projected thereon. Its function is to operate the relay 1081 by energizing the relay coil 1109 at the moment that the predetermined quantity of light referred to is projected thereon from the light source 1133.

As previously explained, however, the delay-action thermostatic switch has delayed the connection of the circuit which includes the photo-cell 1129 and the relay coil 1109 until such time, after the washing operation has commenced, that it is assured that a column of dirty water will be present inside of the discharge duct 1104. However, as the washing operation proceeds and the washing liquid continues to discharge through the discharge duct 1104, it is apparent that the column of dirty water originally established therein will be constantly flushed therethrough and that progressively cleaner and cleaner water will present itself in the transparent portion of the discharge duct, with the result that more and more light will be able to penetrate the transparent section of the discharge duct and fall upon the photo-cell mechanism 1129. Inasmuch as the photo-cell has been adjusted on the basis of tests and predetermined standards, it will function to pass the current therethrough and to thereby energize the relay coil 1109 at the moment when the wash liquid passing through the discharge duct is free from solids to an extent which indicates that a satisfactory washing operation has been completed. In other words, when the wash-

ing operation has been conducted to the point where no further washing is desired, the photo-cell 1129 will then operate to energize the relay coil 1109, which in turn will move the switch elements associated therewith.

When the switch element 1131 is moved into engagement with the contact element 1132, a direct circuit is established through the relay coil 1109 whereby the relay stays energized and the relay switches remain in their new positions irrespective of what may occur at the photo-cell 1129. A further result is that the movement of switch elements 1108 and 1114 serve to disconnect the circuit which was employed for feeding soap and alkali, whereby the solenoids associated with the soap and alkali valves are deenergized and therefore their associated valves are closed. Accordingly, no more soap and alkali can be added irrespective of the action of the photo-cell 1112.

Rinse operation

At the same time that relay 1081 is operated, a fourth relay switch 1134, which is normally open, is moved to closed position. As a result of this action the current which exists in line 1078, as previously described, passes into the relay switch 1134 and then into line 1135. It will be noted from the drawing that line 1135 passes to the right and thence downwardly and then to the left and connects with a third photo-cell mechanism 1136. The other side of the photo-cell 1136 is connected through a line 1137 with one side of the coil 1138 of the relay 1139. The other side of the relay coil is connected through line 1140 with the other current line 1070. The purpose of the circuit thus established is to place the relay coil 1138 under the direct control of the photo-cell 1136.

The photo-cell 1136 is disposed so as to receive light passing through the transparent section 1016 of the discharge duct 1014 from the light source 1142 in substantially the same manner as described in connection with the other photo-cell devices. The light source 1142 is connected directly across the current lines 1121 and 1122 so that it will be illuminated at the same time the other light source devices are illuminated.

The photo-cell 1136 is selected or adjusted on a different basis from that of the photo-cell 1129, as the cell 1136 will act to pass current through its circuit when it has projected thereon the amount of light which indicates that the wash liquid is substantially free from soap. Experiment has shown that the light-transmitting qualities of water and soap in suspension vary with the quantity of soap present therein, with an increased amount of light passing therethrough as the soap content diminishes. Consequently, the photo-cell 1136 is adapted to utilize this characteristic of the soap and water suspension and is adjusted to pass a current through its circuit at that moment when the rinsing water has been rendered substantially free of soap.

Feeding bleach

In addition to the foregoing, the closing of the relay switch 1134 has also served to connect the current line 1078 with line 1143 which passes upwardly and connects with the solenoids, respectively, associated with the valves 1144 and 1145 which are located at the bottom and top of the bleach measuring tank 1146. The bottom valve 1144 is a normally closed valve, whereas the upper valve 1145 is a normally open valve, of a construction similar to that described in connection with

the measuring tanks of the other modifications. In other words, a predetermined measured quantity of bleach is contained in the bleach tank 1146 which is sufficient for one batch of clothes. Inasmuch as only one bleaching treatment is required during a single washing operation, it is only necessary to discharge the contents of the bleach tank once.

Continued operation

Returning now to the operation, it has already been shown that upon the completion of the suds treatment the photo-cell 1129 will be effective to energize the relay 1109 and to move all of the relay switches associated therewith as above indicated. As a result, the rinsing operation is commenced. The water fed under the influence of the thermal control device continues as before, but, as already shown, the feeding of soap and alkali are discontinued. As a result, water at the desired temperature is constantly flushed through the clothes which are being tumbled in the washing machine, and the soap and remaining soil present therein are rinsed out. Furthermore, the photo-cell 1136, which is sensitive to measure the soap content in the rinse water, has been connected for operation, whereby the rinsing of the clothes is continued for the necessary period required for removing substantially all of the soap therefrom.

It will further appear that at the moment the rinsing operation is started, a measured quantity of bleach is discharged into pipe 1131 and caused to pass to the injector nozzle and fed into the washing machine along with the rinsing water. Continuation of the rinsing operation, however, serves to remove the bleach after it has performed its usual function.

It is further apparent that after the rinse water has become sufficiently free of soap to indicate a completion of the rinsing operation, the photo-cell 1136 will be effective to energize the relay coil 1138. The operation of relay coil 1138 serves to terminate the rinsing operation and to initiate timed blue and sour treatments which will now be described.

Blue and sour treatment

When relay coil 1138 is energized, the relay switch 1092 is moved from the full-line position to the dotted-line position or, in other words, is moved so as to break contact with line 1093 and to make contact with line 1076. The effect of this movement of the relay switch 1092 is, first, to disconnect the circuit leading to the automatic thermal control device, whereby from this point on the water fed to the washing machine will be cold; secondly, to break the circuit which includes the heating element 1124 of the delayed thermostatic switch device so as to permit the heating element to cool off preparatory to the next operation; third, to establish a circuit which energizes the timing motor 1061; and fourth, to establish a circuit through which the solenoid 1159 may be impulsed under the direct control of the timing cam 1060.

The first and second actions above indicated are the direct result of the movement of the relay switch 1092 out of engagement with the line 1093, as this connection was depended upon for maintaining the automatic thermal device and the heater 1124 connected to the current source.

The third result, namely, that of establishing a circuit for the timing motor, is accomplished by the relay switch 1092 making contact with the

line 1076. As shown on the drawing, this connection serves to connect the current line 1091 to line 1076 which in turn connects with line 1147 which extends directly to the timing motor. The other side of the timing motor is connected through line 1069 to the other current line 1070.

The fourth result, namely, that of establishing the solenoid-impulsing circuit, is also the result of the contact made between relay switch 1092 and line 1076, because it will be noted that line 1076 connects through switch 1065 (now in dotted-line position) with line 1066 which in turn connects directly with the timer 1060. As previously described, the timer is connected through line 1076 to the solenoid 1059, the latter of which has its other side connected through lines 1068 and 1069 to the other current line 1070.

Action of timer

It will thus appear that the moment the relay 1039 is operated by the photo-cell 1136 as above indicated, current passes from the current source directly through the timer and into the solenoid 1059, whereby the solenoid is immediately given one moving impulse. This initial impulse is established immediately because, as previously described, the timer always comes to rest on a contact position so that current is free to pass there-through in a manner to energize the solenoid 1059. As a result of this initial movement of the solenoid, the ratchet mechanism and consequently the set of cams mounted on the shaft 1032 are moved to the next position in which the switch 1148, associated with the cam 1074, is closed. As will be described in a moment, the closing of this switch causes blue and sour to be fed into the washing machine.

It will be noted at this time, however, that the timing motor is also started, whereby the solenoid and ratchet mechanism will continue to function to advance the timing cams in a step-by-step fashion at predetermined intervals, depending upon the selected character of the timing cam itself. In other words, the intervals may be selected according to the preference of the manufacturer and in relationship to the number of teeth on the ratchet, so as to give blue and sour treatments of the desired duration.

Feeding of blue and sour

The closing of switch 1148 by the cam 1074 as above indicated, causes current to flow from the current line 1082 into line 1149 through the switch 1148 into the contact element 1150 and thence into line 1151. It will be noted from the drawing that line 1150 connects with the solenoids, respectively, associated with the lower and upper valves 1152 and 1153, respectively, which control the feeding of blue from the blue-measuring tank 1154, and also with the solenoids, respectively, associated with the lower and upper valves 1155 and 1156, respectively, associated with the sour-measuring tank 1157.

The lower valves of these tanks are of the normally closed type, whereas the upper valves are of the normally open type and are constructed in a manner similar to the corresponding valves of the blue and sour tanks described in connection with the other modifications. In other words, when current is supplied to the solenoids of these valves, the contents of the tanks, respectively, are discharged.

It will thus be seen that the closing of switch 1148 by means of the cam 1074 serves to feed the measured quantities, respectively, of the blue and

sour into the feed pipe 1031, whereby the same is injected into the water line and thus into the washing machine.

As already indicated, the automatic thermal control mechanism has been disconnected, whereby the blue and sour treatment is performed with cold water. As a result of the introduction of blue and sour as thus described, the clothes contained in the washing machine are given the desired blue and sour treatments and are thereafter further rinsed with cold water.

Blue and sour circuits disconnected

At a suitable time after the blue and sour have been discharged, the timing mechanism brings the high surface of cam 1074 into position to again open the switch 1048, so as to break the circuit which functions to discharge the blue and sour measuring tanks, thereby allowing each of these tanks to refill for the following washing operation.

Water supply disconnected

By the time the clothes have been given a sufficient rinse with cold water following the blue and sour treatments, the timing cams are in such position that the high surface of cam 1073 serves to lift the switch 1083 and break the circuit which has served to open the water valve. In consequence, the supply water to the washing machine is shut off.

Dump valve opened

The timing cam continues to move, however, and shortly after the water is shut off the high surface of cam 1072 is brought into position to lift the switch 1098 which connects with the line that has served to energize the dump valve operating mechanism. In consequence, the dump valve 1009 at the bottom of the washing machine moves to open position and all of the wash liquid therein is discharged.

Soap and alkali circuits disconnected

It will be noted at this point that the interruption of the dump valve circuit also interrupts the current line to the soap and alkali valves, but as this circuit has been previously broken at the relay switch 1081, this has no effect.

Stopping operation

The timer continues to move and is finally brought to its ultimate position, as shown in the drawing, in which position the high surface of the cam 1071 is moved to lift the switch 1055 so as to break the main current line to the entire apparatus and to thus deenergize the relay coil 1043 of the magnetic relay 1039. This results in the magnetic relay switch being moved to open position, whereby all current to the control mechanism and to the motor is shut off. In consequence, the washing machine is brought to rest and the entire operation stops.

Furthermore, the final position of the timer moves cam 1075 into the position shown, in which the low portion of the cam is uppermost, whereby the switch 1065 is permitted to drop so as to make contact with line 1064 and to break contact with line 1076.

Device conditioned for next operation

The contact with line 1064 conditions the apparatus for the next operation and provides the circuit which will give the solenoid 1059 its initial impulse, as previously described, when the

starting button 1062 is again pushed. It should be noted that the final position of the timer and particularly cam 1071 serves to break the main current line, whereby all current which would be required for further movement of the timer is disconnected, and that as a result the timer itself is brought to rest in the final position referred to and shown in the drawing. As previously indicated, this is the position which the timer should be in to initiate a subsequent starting operation by depressing the starting button 1062.

SUMMARY OF OPERATION—THIRD FORM

After the clothes to be washed are placed in the washer, the starting button is pressed and immediately the motor for the washing machine starts to turn the washing cylinder. At the same time, the dump valve, located at the bottom of the machine, is closed and, in addition, water at the desired temperature, as regulated by the thermal control mechanism, is introduced into the washer. This water enters the washer by being projected from a lower position in an upward angular direction counter to the movement of the clothes under the influence of the rotating cylinder.

At the same time that the water is turned on, soap and alkali are fed to the water inlet pipe so that by a suitable injection system, soap and alkali are fed into the water line in quantities somewhat proportional to the amount of water. In view of the fact that the dump valve is closed, the level of the water in the washing machine rises until it reaches an outlet which is of sufficient size to discharge water at substantially the same rate that it is introduced, whereby the flow of water, soap and alkali through the washing machine, in contact with the clothes, is continuous.

A second outlet is provided above the first outlet which is adapted to serve as a discharge for soap suds. This upper outlet is placed at a level which is substantially correct for the suds during the washing treatment. When the suds in the washer are sufficient to discharge through the upper level, the suds in the discharge pipe interrupt the passage, through a transparent section of the pipe, of light which emanates from an associated lamp and pass in the direction of a photo-electric cell placed on the opposite side of the transparent section. This photo-electric cell is connected in circuits which control the feed of soap and alkali. In addition, these circuits depend upon the falling of a predetermined amount of light upon the photo-electric cell in order to feed soap and alkali. As a result, when suds are present in the discharge pipe the feed of soap and alkali is discontinued, but so long as the suds are not being discharged through said discharge pipe, soap and alkali are fed in with the wash water. In this way the soap and alkali are fed in according to the need therefor.

Associated with the lower discharge outlet is a second photo-electric mechanism which includes a lamp and a photo-electric cell. This mechanism was connected at the commencement of the washing operation and is constantly scanning the water discharged through the discharge pipe. When the water is sufficiently clear to indicate that the suds treatment is complete, the photo-electric cell is energized by the light of the lamp falling thereon, whereupon the feeding of soap and alkali is permanently discontinued for the particular washing treatment involved. Not-

withstanding the discontinuance of the feed of soap and alkali, the washer continues to rotate and the water at the desired temperature continues to enter the washing machine in the prescribed manner, so that a suitable rinsing treatment ensues. The discharge of the rinsing liquid occurs through the same discharge means as that provided for the discharge of the washing liquid.

The second photo-electric mechanism referred to is connected in a circuit which includes a bi-metallic switch member and an associated heating coil or other suitable delayed action mechanism. This switch and heating coil function when the photo-electric mechanism is to be connected for operation, and at that time the heating coil is directly connected to the current source, with the result that it gradually heats up and heats the bi-metallic switch, which moves and closes a connection with the photo-electric mechanism referred to. The purpose of this is to withhold the action of the photo-electric mechanism for a limited period to make sure that it will not operate at the outset before the clear water which is introduced in the washer has had a chance to pick up enough soil to prevent the unintended operation of the photo-electric mechanism.

The photo-electric mechanism which operates to cut off the soap and alkali feed also serves to disconnect its own circuit and connect a rinse photo-electric mechanism. This rinse photo-electric mechanism comprises a lamp and photo-electric cell, both of which are associated with a transparent section of the discharge pipe. The sensitivity of this mechanism is adjusted, on the basis of predetermined standards, to control the rinsing treatment.

Simultaneously with the commencement of the rinsing operation a predetermined quantity of bleach is introduced by a mechanism which is so adjusted that only one charge of bleach can occur during the rinsing period.

The rinsing treatment is continued until such time as a predetermined degree of clarity is present in the rinsing liquid. At this point the rinse photo-electric cell acts and terminates the rinse by causing several events to occur, namely:

1. The thermal control mechanism to be disconnected;
2. The heater circuit above referred to, to be disconnected so that the heater may cool off for the next washing operation;
3. A circuit for the timing motor to be established; and
4. A circuit for connecting a timing motor and a cam set operated solenoid to be established.

From this point on, the operation is under the control of a multiple cam mechanism which advances under the control of a timer. This cam mechanism makes contacts which cause a prescribed quantity of blue and a prescribed quantity of sour to be fed in the washer along with the water which is continuously flowing through the washer, as above indicated. The blue and sour treatments are carried out, however, with cold water instead of with warm water, because as previously mentioned the thermal control mechanism is disconnected.

Finally, by the action of the cams driven by the timer, the blue and sour circuits are disconnected and the water supply circuit is also disconnected.

Thereafter, the dump valve is opened by means of the cam and the soap and alkali circuits are disconnected. The final function of the cam mechanism is to shut off the operating motor and

to reset and recondition all parts of the control mechanism so as to prepare the same for the next operation.

INVENTION IS NOT LIMITED TO DISCLOSED EMBODIMENTS

This invention may be applied with an indicating or signaling device such as lights or other similar means which may be connected in any or all of the operating circuits which have been described in the illustrated forms of this invention. In such instances the indicating means may be connected in the circuit in addition to the various electrically operated control devices previously described, or they may be in substitution of such control mechanisms. In the latter event, the mechanism of this invention will serve as a control mechanism through indications to the operator who may follow such indications by manual movement of the valves or other parts according to the indications given. Therefore, it is to be understood that unless the following claims are specifically limited to particular control mechanism, the circuits which are selectively energized are to be considered to include signal or indicator circuits as well as circuits for operating means as described.

As already indicated, this invention is not restricted to any particular washing apparatus. Whereas the inventions have been illustrated as applied to horizontally disposed cylindrical commercial machines, it is to be understood that the invention is to be construed broadly and that it is applicable to all types of devices. For instance, the invention is applicable to vertical and other types of machines, including household machines as well as all other washing equipment.

It is to be understood that the invention in its broadest sense is not to be restricted to any particular kind of feeding devices for the soap, alkali, bleach, and other agents, nor is it limited to the introduction of these materials in liquid form. It will be apparent to those skilled in the art that other types of feeding devices can be employed, and that the agents used may be introduced in any form, including solid form if such should be practical and preferred.

In addition, in the foregoing specification and in the appended claims, the term "detergent" is to be construed as covering soap as well as all surface-active agents, such as, for instance, sulfonated alcohol or like material. In other words, the term "detergent" is intended to cover all materials which act in the capacity of or as substitutes for soap or similar detergents in washing or cleansing clothes or like articles.

Furthermore, it is to be understood particularly in connection with the invention illustrated in the second and third forms, that the analysis of a representative portion of the liquid need not be carried out at a location below the level of the liquid from which it is taken, as is the case in the disclosed embodiments. For instance, a highly satisfactory result is obtained when the analysis is conducted at a more elevated position by drawing up that portion of the liquid which is to be employed in the analysis. This has been satisfactorily accomplished by means of drawing up a portion of the liquid by the action of an injector, and when this method is utilized it is found that the tube through which the light is projected is kept free from sediment and dirt, which eliminates the necessity for frequent cleaning. In consequence, in practice it is contemplated that an injector or similar means may be

employed for elevating a representative portion of the liquid to be analyzed, if such should be desired.

It is to be understood that in the second illustrated form of the invention it is not essential to have the testing liquid withdrawn continuously, as such withdrawal may be conducted only for a limited period as, for instance, during the time that the analysis mechanism is in operation. If this modification is employed, an electric circuit could be utilized which would open the valve and permit the flow of test liquid at or about the same time that the testing circuit is energized.

In addition, the successful operation of the invention does not require that the washing machine operate at any particular speed. Although certain speeds no doubt are preferred for the best results in particular instances, the speed of the washer is not critical to this invention, nor is the invention limited to washers which reverse their direction of movement as it may be applied with good results to unidirectional washers.

As another feature, this invention contemplates the use of a stepping relay which may be manually set for a maximum number of possible operations. This could be used if desired to constitute a safety limit for the control. In other words, if anything should go wrong whereby the apparatus in performance should unduly repeat the suds operations, the stepping relay would be stepped one point or notch for each suds operation until the machine carried out the number of suds operations manually selected by the operator. When this maximum number of suds operations are completed the machine would automatically stop, whereby a safe operating period would be provided. For this purpose the type of mechanism shown in Figures 21 to 23, inclusive, could be employed by properly connecting the same in the particular circuit for operation of a final cut-off switch.

What is claimed is:

1. The combination with a cleaning machine having a receptacle, of a dump valve and a valve controlled inlet for a cleaning liquid, control mechanism for said cleaning machine for causing said cleaning machine to perform various cleaning treatments differing as to their suitability to different soil conditions, said control mechanism including means automatically responsive to a property of the contents of said receptacle which varies with the amount of soil present in said receptacle, and other means responsive to said first-named means for causing said control means to operate said dump valve and said valve controlled inlet for a cleaning liquid, and thereby to effect a particular cleaning treatment which is adjusted, on the basis of predetermined standards, to the soil condition existing in said receptacle at the commencement of said cleaning treatment.

2. The combination with a cleaning machine having a receptacle, discharge means and cleaning liquid inlet means, of control mechanism for said cleaning machine, comprising means for analyzing at least a representative portion of the cleaning liquid and for responding to a property thereof which varies with the amount of soil present in said receptacle, and means controlled by said analyzing means for determining the extent of the cleaning treatment according to the character of the detected property to which the analyzing means has responded.

3. The combination with a cleaning machine

having a receptacle, discharge means and cleaning liquid inlet means, of control mechanism for said cleaning machine for causing said cleaning machine to perform various cleaning procedures, differing as to their suitability to different soil conditions, said control means comprising means for analyzing at least a representative portion of the cleaning liquid and for responding to a property thereof which varies with the amount of soil present in said receptacle, and means controlled by said analyzing means for causing the material to be cleaned, to be cleaned by a particular procedure according to the character of the detected property to which the analyzing means has responded said particular procedure including the operation of said discharge means and said liquid inlet means.

4. The combination with a cleaning machine having a receptacle, discharge means and cleaning liquid inlet means, of control mechanism for said cleaning machine for causing said cleaning machine to perform various cleaning procedures involving different periods of time to which the articles being cleaned are subjected according to the different soil conditions, said control means comprising means for analyzing at least a representative portion of the cleaning liquid and for responding to a property thereof which varies with the amount of soil present in said receptacle, and means controlled by said analyzing means for causing the material to be cleaned, to be cleaned for a particular period of time according to the character of the detected property to which the analyzing means has responded the procedure carried out including the operation of said discharge means and said cleaning liquid inlet means.

5. The combination with a cleaning machine having a receptacle, discharge means and cleaning liquid inlet means, of control mechanism for said cleaning machine for causing said cleaning machine to perform various cleaning procedures involving different numbers of separate soil-removing treatments, said procedures thereby differing as to their suitability to different soil conditions, said control means comprising means for analyzing at least a representative portion of the cleaning liquid and for responding to a property thereof which varies with the amount of soil present in said receptacle, and means controlled by said analyzing means for causing the material to be cleaned, to be cleaned by a particular number of separate soil-removing treatments as determined by the character of the detected property to which the analyzing means has responded each of said soil-removing treatments including the operation of said discharge means and said cleaning liquid inlet means.

6. The combination with a cleaning machine of the character described, of automatic control mechanism therefor, comprising means for introducing cleaning liquid into said cleaning machine, means for shutting off said cleaning liquid introducing means after a predetermined amount of cleaning liquid has been introduced into said cleaning machine, and means for discharging cleaning liquid from said cleaning machine, and means for causing said cleaning liquid introducing means, shutting off means, and means for discharging cleaning liquid from said cleaning machine, respectively, to perform their initial operations and means for causing the same to repeat their operations, and means for rendering said repeating means ineffective after said op-

erations have been repeated a particular number of times.

7. The combination of a cleaning machine, an automatic control mechanism therefor comprising means for introducing cleaning liquid, means for introducing detergent, and discharge means, said means for introducing cleaning liquid being opened only after said discharge means is closed, said detergent introducing means being opened only when said cleaning liquid introducing means is closed, said detergent introducing means being shut off when a predetermined excess of said detergent in relation to the soil present has been introduced, said means for introducing cleaning liquid, means for introducing detergent, and discharge means being adapted for cooperative action to perform a succession of detergent treatments in said cleaning machine, and means responsive to the soil condition in said cleaning machine for determining the number of said detergent treatments to be carried out.

8. The combination of a cleaning machine, an automatic control mechanism therefor, comprising means for introducing cleaning liquid, means for introducing detergent, and discharge means, said means for introducing cleaning liquid being opened only after said discharge means is closed, said detergent introducing means being opened only when said cleaning liquid introducing means is closed, said detergent introducing means being shut off when a predetermined excess of said detergent in relation to the soil present has been introduced, said means for introducing cleaning liquid, means for introducing detergent, and discharge means being adapted for cooperative action to perform a succession of detergent treatments in said cleaning machine, and means for measuring the amount of detergent introduced on the first detergent treatment for automatically repeating the detergent treatment a number of times as determined by said means for measuring the amount of detergent so introduced.

9. The combination of a cleaning machine, an automatic control mechanism therefor comprising means for introducing cleaning liquid, means for introducing detergent, and discharge means, said means for introducing cleaning liquid being opened only after said discharge means is closed and being shut off when the cleaning liquid has reached a predetermined level in said cleaning machine, said detergent introducing means being opened only when said cleaning liquid introducing means is closed, said detergent introducing means being shut off when a predetermined excess of said detergent in relation to the soil present has been introduced, said means for introducing cleaning liquid, means for introducing detergent, and discharge means being adapted for cooperative action to perform a succession of detergent treatments in said cleaning machine, and means responsive to the soil condition in said cleaning machine for determining the number of said detergent treatments to be carried out.

10. The combination with a cleaning machine of the character described, of automatic control mechanism therefor comprising means for automatically introducing a cleaning liquid and a detergent, and causing a single cleaning treatment of predetermined duration to occur, an analyzing means associated with said machine for analyzing a representative portion of the cleaning liquid during said treatment, and means governed by said last-named means for causing a repetition of said treatment when the amount of soil in the

analyzed portion of the cleaning liquid is above a certain predetermined standard and for preventing a repetition of said treatment when the amount of soil in the analyzed portion of said cleaning liquid is below a certain predetermined standard.

11. In combination with a cleansing machine having a receptacle for material to be cleaned and a cleaning liquid, means permitting the introduction and removal of the material to and from the receptacle, powered means for agitating the material and the liquid, powered control means for admitting and discharging the liquid, means for determining the presence of foreign matter in the liquid during the cleansing operation, and means responsive to said determining means for actuating said powered control means to continue the cleansing action until the foreign matter reaches a predetermined minimum.

12. The combination with a washing machine having a washing receptacle, a dump valve and valve controlled inlets respectively for water and detergent, of control mechanism for said washing machine comprising means automatically responsive to a property of the initial washing liquid in said receptacle which is variable on the basis of predetermined standards with the amount of soil present in said receptacle, and means controlled by said automatically responsive means for producing washing and rinsing treatments commensurate, on the basis of predetermined standards, with the soil condition existing at the commencement of the washing treatment.

13. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising means for automatically introducing water into the washing machine, means for automatically introducing soap into said washing machine, means for automatically terminating the introduction of water upon the water reaching a predetermined level in said washing machine, means for automatically terminating the introduction of soap upon the soap suds in said washing machine reaching a predetermined level, and means for causing said water introducing means, soap introducing means and terminating means therefor, respectively, to repeat their operations successively and means for rendering said repeating means ineffective, after said operations have been repeated a predetermined number of times.

14. The combination with a washing machine of the character described, of an automatic control mechanism therefor comprising water introducing means, means for introducing soap at a uniform rate, discharge means, and selecting means operating at a uniform rate of speed capable of occupying a particular position upon the passing of a predetermined period of operating time, said selecting means comprising a circuit selector for selectively connecting a plurality of control circuits for determining the total extent of the washing operation and means for starting said selecting means in operation when said soap introducing means is opened and for stopping the same when said soap introducing means is closed.

15. The combination with a washing machine having a receptacle, of automatic control mechanism therefor comprising water introducing means, soap introducing means, discharge means, and timing means for determining the duration of a washing treatment, said discharge means being closed when said water introducing means is open, said soap introducing means being opened simultaneously with the opening of said water in-

roducing means, said timing means being inactive when said water introducing means is open, said control mechanism including means for introducing additional soap after said water introducing means is shut off, said means for introducing additional soap being adapted to automatically shut off when the soap suds in said washing machine have reached a predetermined level, and said timer being inactive when said means for introducing additional soap is active.

16. The combination with a washing machine having a receptacle, of automatic control mechanism therefor comprising water introducing means, soap introducing means, discharge means, and timing means for determining the duration of a washing treatment, said discharge means being closed when said water introducing means is open, said soap introducing means being opened simultaneously with the opening of said water introducing means, said timing means being inactive when said water introducing means is open, said control mechanism including means for introducing additional soap after said water introducing means is shut off, said means for introducing additional soap being adapted to automatically shut off when the soap suds in said washing machine have reached a predetermined level, said timing means being inactive when said means for introducing additional soap is active, and said timing means being automatically started when said means for introducing additional soap is shut off.

17. The combination of a washing machine, an automatic control mechanism therefor comprising means for introducing water, means for introducing soap, and discharge means, said means for introducing water being opened only after said discharge means is closed, said soap introducing means being opened only when said water introducing means is closed, said soap introducing means being shut off when a predetermined excess of said soap in relation to the soil present has been introduced, said means for introducing water, means for introducing soap, and discharge means being adapted for cooperative action to perform a succession of soap treatments in said washing machine, and means responsive to the soil condition in said washing machine for determining the number of said soap treatments to be carried out.

18. The combination of a washing machine, an automatic control mechanism therefor comprising means for introducing water, means for introducing soap, and discharge means, said means for introducing water being opened only after said discharge means is closed, said soap introducing means being opened only when said water introducing means is closed, said soap introducing means being shut off when a predetermined excess of said soap in relation to the soil present has been introduced, said means for introducing water, means for introducing soap, and discharge means being adapted for cooperative action to perform a succession of soap treatments in said washing machine, and means for measuring the amount of soap introduced on the first soap treatment for automatically repeating the soap treatment a number of times as determined by said means for measuring the amount of soap so introduced.

19. The combination of a washing machine, an automatic control mechanism therefor comprising means for introducing water, means for introducing soap, and discharge means, said means for introducing water being opened only after said

discharge means is closed and being shut off when the water has reached a predetermined level in said washing machine, said soap introducing means being opened only when said water introducing means is closed, said soap introducing means being shut off when a predetermined excess of said soap in relation to the soil present has been introduced, said means for introducing water, means for introducing soap, and discharge means being adapted for cooperative action to perform a succession of soap treatments in said washing machine, and means responsive to the soil condition in said washing machine for determining the number of said soap treatments to be carried out.

20. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising water introducing means, means for introducing soap at a uniform rate in quantity varying in each particular introducing operation with variations in soil content in said cleaning machine and discharge means, said discharge means being closed when said water introducing means is open, said soap introducing means being opened after said discharge means is closed and being shut off when the soap suds have reached a predetermined level, said water introducing means, soap introducing means, and discharge means being adapted for cooperative action to perform a succession of suds treatments in said washing machine and means for measuring the time interval during which soap was so introduced, and means operated by said time measuring means for determining the extent of the washing treatment to be carried out.

21. The combination of claim 20, characterized in that said control mechanism includes means for automatically repeating suds operations a number of times as determined by the means for measuring the time interval during which soap is introduced.

22. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising water introducing means, means for introducing soap at a uniform rate, and discharge means, said discharge means being closed when said water introducing means and said soap introducing means are open, said water introducing means being shut off when the water reaches a predetermined level in said washing machine, and said soap introducing means being shut off when the soap suds have reached a predetermined level, said water introducing means, soap introducing means, and discharge means being adapted for cooperative action to perform a succession of suds treatments in said washing machine and means for measuring the time interval during which said soap is so introduced, and means operated by said time measuring means said last-named means serving to determine the extent of the washing operation to be carried out.

23. The combination of claim 22, characterized in that said control mechanism includes means for automatically repeating suds treatments a number of times as determined by said means for measuring the time interval during which said soap is introduced.

24. The combination of a washing machine of the character described, of automatic electrically operated control mechanism therefor comprising a set of analyzer cams for controlling a washing operation, a plurality of sets of different formula cams each adapted to control additional washing operations each varying from the other in extent

of washing effect, a set of selector cams for selecting one of said sets of formula cams, and a set of timer cams comprising a particular timer cam for each of said sets of cams, respectively, means connecting each timer cam to its corresponding cam set, and means for operating said set of selector cams during the washing operation controlled by said analyzer cams, said set of selector cams being advanced to an extent corresponding to the soil condition present in the washing machine during the operation of said set of selector cams and serving to thereby select an appropriate formula cam.

25. The combination defined in claim 24, characterized in that the control mechanism includes means connected to the set of analyzer cams which automatically causes the washing operation controlled by said set of analyzer cams to be performed, and means adapted to be connected to one of said formula cam sets which automatically causes subsequent washing operations to be performed.

26. The combination with a washing machine of the character described, of automatic, electrically operated control mechanism therefor comprising a set of analyzer cams for conducting an initial washing operation employing soap suds, a plurality of sets of differing formula cams, and a selector for connecting one of said sets of formula cams for conducting subsequent washing operations employing soap suds.

27. The combination with a washing machine of the character described, of automatic, electrically operated control mechanism therefor comprising a set of analyzer cams for conducting an initial washing operation employing soap suds, a plurality of sets of differing formula cams, and a selector for connecting one of said sets of formula cams for conducting subsequent washing operations employing soap suds and rinse operations.

28. The combination defined in claim 27, characterized in that said control mechanism includes a timer for driving, respectively, at a predetermined and uniform rate of speed, said set of analyzer cams and the selected set of said formula cams, and said selector.

29. The combination defined in claim 27, characterized in that said set of analyzer cams controls means for introducing water.

30. The combination defined in claim 27, characterized in that said set of analyzer cams controls means for introducing soap.

31. The combination defined in claim 27, characterized in that said set of analyzer cams controls means for introducing alkali.

32. The combination defined in claim 27, characterized in that said set of analyzer cams controls means for introducing water and soap.

33. The combination defined in claim 27, characterized in that said analyzer cam set controls means for introducing water until the water in the washing machine reaches a predetermined level, then introducing soap until the suds therein reach a predetermined level, and then conducting a suds treatment for a predetermined time period.

34. The combination defined in claim 27, characterized in that said analyzer cam set controls means for introducing water until the water in the washing machine reaches a predetermined level, and introducing soap until the suds therein reach a predetermined level, said selector operating in response to the amount of soap so introduced.

35. The combination defined in claim 27, char-

acterized in that said analyzer cam set controls means for introducing water until the water in the washing machine reaches a predetermined level, and introducing soap at a uniform rate until the suds therein reach a predetermined level, and connecting said selector for operation at a uniform rate of speed during the soap introducing period.

36. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising means for introducing water, means for introducing an amount of soap proportional to the amount of soil present, a plurality of sets of control mechanisms for effecting different washing operations for different amounts of soil to be removed, and means for automatically selecting a particular one of said sets of control mechanisms according to the amount of soap introduced and automatically connecting the same for controlling the operation.

37. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising means for introducing water, means for introducing an amount of soap proportional to the amount of soil present, a plurality of sets of control mechanisms for effecting different washing and rinsing operations for different amounts of soil to be removed, and means for automatically selecting a particular one of said sets of control mechanisms according to the amount of soap introduced and automatically connecting the same for controlling the operation.

38. In an electrically controlled washing machine of the character described, the sub-combination consisting of a receptacle for said washing machine, an electrically controlled water inlet means connected to said receptacle, an electrically controlled soap inlet means, and an electrical circuit for energizing said electrical control means for said water inlet means, said circuit including means responsive to liquid level, and a second circuit extending to the control means for said soap inlet means and said means responsive to liquid level being connected to make and break the circuit for said water inlet means and to simultaneously break and make the circuit for said soap inlet means.

39. In an electrically controlled washing machine of the character described, the sub-combination consisting of a receptacle, electrically controlled water inlet means, a circuit therefor, electrically controlled soap inlet means and a pair of separate circuits therefor, and a liquid level responsive means connected to each of said circuits, means for energizing the circuit for said water inlet means and one of said circuits for said soap inlet means to simultaneously introduce water and soap into said receptacle when said liquid level responsive means is in one position, and when said liquid level responsive means is in a second position to shut off the water inlet means and the previously energized circuit for said soap inlet means, and to energize said second circuit for said soap inlet means for introducing additional soap.

40. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising a plurality of cam sets, a timer adapted to be selectively connected to one of said cam sets for driving the same at a uniform rate of speed, and a selector, one of said cam sets being connected through electrical circuits to water and soap inlet means

whereby water is introduced into said washing machine, a liquid level responsive means associated with said washing machine for energizing the soap inlet control circuit when the water has reached a predetermined level and simultaneously energizing the selector operating circuit, and other liquid level responsive means in said washing machine for disconnecting the flow of soap and the movement of said selector.

41. The combination of claim 40, characterized in that the selector, according to its position, automatically connects one of said other control cam sets and disconnects the first operated cam set.

42. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising a set of controlling cams and a timer adapted to drive said set of cams at a uniform rate of speed, water and soap inlet means and electric controls therefor connected for operation by said set of cams, and liquid level responsive means associated with said washing machine for disconnecting said soap feeding circuit when the soap suds in said washing machine reach a predetermined level and at the same time connecting for operation said timer, said liquid level responsive means serving to re-establish said soap feeding circuit and to disconnect said timer when and if the soap suds in said washing machine fall below said predetermined level.

43. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising a set of controlling cams and a timer adapted to drive said set of cams at a uniform rate of speed, water and soap inlet means and electric controls therefor connected for operation by said set of cams, and liquid level responsive means associated with said washing machine for connecting said timer when the soap suds in said washing machine reach a predetermined level, said liquid level responsive means serving to disconnect said timer when and if the soap suds in said washing machine fall below said predetermined level.

44. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising means for automatically introducing water and a detergent and causing a single suds treatment of predetermined duration to occur, an analyzing means associated with said washing machine for analyzing a representative portion of the washing liquid during said suds treatment, and means governed by said last-named means for causing a repetition of said suds treatment when the amount of soil in the analyzed portion of said washing liquid is above a certain predetermined standard, and for preventing a repetition of said suds treatment when the amount of soil in the analyzed portion of said washing liquid is below a certain predetermined standard, said control mechanism including means for causing rinsing operations to occur, which means is connected to the analyzing means, and said analyzing means further acting to connect said rinsing means when the amount of soil in the analyzed portion of said washing liquid is below a certain predetermined standard.

45. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising means for automatically introducing water and causing a single rinsing treatment of predetermined duration to occur, an analyzing means associated with said washing machine for analyzing a representative

portion of the rinsing liquid during said rinsing treatment, and means governed by said last-named means for causing a repetition of said rinsing treatment when the amount of soap and other foreign matter in the analyzed portion of said washing liquid is above a certain predetermined standard, and preventing a repetition of said rinsing treatment when the amount of soap and other foreign matter in the analyzed portion of said washing liquid is below a certain predetermined standard.

46. The combination defined in claim 45, characterized in that said control mechanism includes means for causing blue and sour treatments to occur, which means is connected to the analyzing means, and said analyzing means further acting to connect said means for causing blue and sour treatments to occur when the amount of soap and other foreign matter in the analyzed portion of said washing liquid is below a certain predetermined standard.

47. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising a cam set and circuits therefor for causing a plurality of suds treatments, and a second cam set and circuits therefor for causing a plurality of rinsing treatments, electrically operated analyzing mechanism associated with said washing machine for causing the control of said washing machine to be shifted from said first cam set to said second cam set when the soil present in the washing machine is below a certain predetermined standard.

48. The combination of claim 47, characterized in that said analyzing means comprises a light source and a photoelectric cell disposed on opposite sides of a transparent conductor adapted to contain liquid taken from the washing machine.

49. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising a cam set and circuits therefor for causing a plurality of suds treatments, and a second cam set and circuits therefor for causing a plurality of rinsing treatments, electrically operated analyzing mechanism associated with said washing machine for causing the control of said washing machine to be shifted from said first cam set to said second cam set when the soil present in the washing machine is below a certain predetermined standard, and a second analyzing means connected to stop said rinsing cam set when the purity of the rinse water reaches a certain predetermined standard.

50. The combination of claim 49, characterized in that said analyzing means comprise light sources and photo-electric cells disposed on opposite sides of transparent conductors adapted to contain liquid taken from the washing machine.

51. In combination with an automatically controlled washing machine of the character described, the sub-combination consisting of a receptacle, means for introducing water and two circuits therefor, and means for introducing soap and a circuit therefor, and three liquid level responsive mechanisms associated with said receptacle, one of said mechanisms being connected to complete and interrupt one of the water circuits and the soap feeding circuit, the second of said mechanisms being operative to deenergize said soap feeding circuit, and the third of said mechanisms being operative to deenergize said second water feeding circuit.

52. The combination with a continuously operating washing machine having a receptacle, of

automatic control mechanism therefor comprising means for continuously introducing water and detergent in said receptacle, means for continuously withdrawing water and detergent therefrom, and means for determining when the soil in said withdrawn water and detergent falls below a predetermined standard and for discontinuing the soap feed when such condition occurs.

53. The combination defined in claim 52, further characterized in that means for determining when the soil falls below a certain predetermined standard comprises a photo-electric cell and a light source associated therewith.

54. The combination with a continuously operating washing machine having a receptacle, of automatic control mechanism therefor comprising means for continuously introducing water and detergent in said receptacle, means for continuously withdrawing water and detergent therefrom, means for determining when the soil in said withdrawn water and detergent falls below a predetermined standard and for discontinuing the soap feed when such condition occurs, and other means for determining when the quantity of soap in the withdrawn water falls below a certain predetermined standard and for discontinuing the rinsing operation when such event occurs.

55. The combination defined in claim 54, further characterized in that the means for determining when the soil falls below a certain predetermined standard comprises a photo-electric cell and a light source associated therewith, and said other means comprises a photo-electric cell and a light source associated therewith.

56. The combination with a cleaning machine of the character described, of automatic control mechanism therefor comprising means for introducing cleaning liquid and detergent in said cleaning machine and causing a cleaning treatment to occur, means associated with said cleaning machine responsive to predetermined characteristics of said cleaning liquid which vary with the amount of soil present in said cleaning machine, and other means governed by said first-named means for causing a repetition of said cleaning treatment when the amount of soil in the cleaning liquid is above a certain predetermined standard, and for preventing a repetition of said cleaning treatment when the amount of soil in said cleaning liquid is below a certain predetermined standard.

57. The combination with a cleaning machine of the character described, of automatic control mechanism therefor comprising means for introducing cleaning liquid and detergent in said cleaning machine and causing a single cleaning treatment of predetermined duration to occur, means associated with said cleaning machine responsive to predetermined characteristics of said cleaning liquid, and other means governed by said first-named means for causing a repetition of said cleaning treatment when the amount of soil in the cleaning liquid is above a certain predetermined standard, and for preventing a repetition of said cleaning treatment when the amount of soil in said cleaning liquid is below a certain predetermined standard.

58. The combination with a cleaning machine of the character described, of control means therefor comprising means causing cleaning liquid to flow continuously through said cleaning machine while maintaining a predetermined quantity of cleaning liquid in said machine, means for feeding detergent into said cleaning machine substantially in that quantity which will

provide a detergent suds blanket of predetermined thickness on said cleaning liquid, means capable of responding to a characteristic of the discharged cleaning liquid which varies with the soil present therein and being connected to cause said detergent feed to be shut off during the portion of the treatment following the moment when the quantity of soil present in the discharged cleaning liquid falls below a certain predetermined amount.

59. The combination with a cleaning machine of the character described, of automatic control mechanism therefor, comprising means for introducing cleaning liquid into said cleaning machine, means for automatically shutting off said cleaning liquid introducing means when the cleaning liquid reaches a predetermined level in said cleaning machine, means for discharging the cleaning liquid from said cleaning machine, a single set of cams and means for advancing said single set of cams, said single set of cams causing for each cycle of movement one operation of said cleaning liquid introducing means, means for shutting off said cleaning liquid introducing means, discharging means, manually operable means causing said single set of cams to initially start and to go through its first cycle of operation, and means automatically causing said single set of cams to undergo an additional cycle of operation whenever, in any particular cleaning operation, an additional cycle of operation is required to bring the articles being cleaning to a predetermined degree of cleanliness.

60. The combination with a cleaning machine of the character described, of automatic control mechanism therefor comprising means for introducing cleaning liquid, means for introducing detergent, and timing means for controlling the duration of the cleaning operation, means for causing said cleaning liquid introducing means to operate and to cause said detergent introducing means to operate after the operation of said cleaning liquid introducing means has terminated, said timing means being inactive during the periods when said cleaning liquid and detergent introducing means are in operation, but being caused to commence its operation immediately upon the termination of the operation of said detergent introducing means.

61. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising water introducing means, soap introducing means, and discharge means, an automatic actuating means for causing said water introducing means, soap introducing means and discharge means to operate a plurality of times in succession to produce a plurality of suds operations, and means connected to said automatic actuating means for determining the time interval of each of said suds operations, said means for determining the time interval being inactive during the period of time the soap is being introduced in each of said suds operations, respectively, whereby the soap introducing periods are not included in the intervals of said suds operations, respectively.

62. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising water introducing means, soap introducing means, and discharge means, an automatic actuating means for causing said water introducing means, soap introducing means and discharge means to operate a plurality of times in succession to produce a plurality of suds operations, and means connected

to said automatic actuating means for determining the time interval of each of said suds operations, said automatic control mechanism including means for measuring the soap introduction period for the first suds operation, and means for selecting and determining the number of suds operations to be carried out according to the measurement of said soap introducing period.

63. The combination with a washing machine of the character described, of automatic control mechanism therefor comprising water introducing means, soap introducing means, and discharge means, an automatic actuating means for causing said water introducing means, soap introducing means and discharge means to operate a plurality of times in succession to produce a plurality of suds operations, and means connected to said automatic actuating means for determining the time interval of each of said suds operations, said means for controlling the time interval being inactive during the period of time the soap is being introduced in each of said suds operations, respectively, and said automatic control mechanism including means for measuring the soap introduction period for the first suds operation, and means for selecting and determining the number of suds operations to be carried out according to the measurement of said soap introducing period.

64. The combination with a cleaning machine having a receptacle, discharge means and cleaning liquid inlet means, of control mechanism for said cleaning machine comprising means for analyzing at least a representative portion of said cleaning liquid and for responding to a property thereof, and means controlled by said analyzing means for causing a particular number of separate detergent treatments according to the character of the detected property to which said analyzing means has responded, said control mechanism including means for introducing for each separate detergent treatment an amount of detergent proportional to the amount of soil present during each such detergent treatment, respectively.

65. The combination with a washing machine having a washing receptacle, discharge means and washing liquid inlet means, of control mechanism for said washing machine comprising means for analyzing at least a representative portion of the washing liquid and for responding to a property thereof, and means controlled by said analyzing means for causing the material to be washed, to be washed by a particular procedure according to the character of the detected property to which the analyzing means has responded, said control mechanism also including means for introducing detergent in amount proportional to the amount of soil present during such treatment.

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