METHODS AND DEVICES FOR CONTROL OF FLUIDIC SYSTEMS

Method and apparatus for control of a process for processing goods (2) with liquids (3). The transport of liquid to and from the goods being controlled by the physical state of the process goods, which is sensed by sensors (6). At a predetermined condition of the process goods sensed by the sensors, the transport of liquid is interrupted or changed by the valve means (4) and by the control unit (8), receiving sensor signals (7). By coordinated quantity measuring (5) of the transport of liquid and by sensing of said sensors the process parameter values are established for control of the process. Method and apparatus (206) for optical controlling and/or monitoring of fluid systems and fluid components. Light is emitted by light emitting means (204), included in an optical link (199), comprising a light guide (197), at least two series-connected optical sensors (194, 195) and/or transducers (205) and detecting means (201). The combined signal (200) received is analysed, sensor signals generated by control and monitoring sensors being separated for generation of corresponding control or monitoring signals (202, 203). Flow throttling-measuring device for fluids, comprising a first main chamber for quantity measurement including a sensing zone (III), an inlet zone (II) and an outlet zone (IV) and a second main chamber (I) and a third main chamber (V) intended for flow regulation. Disordered flow generated in the second main chamber and the third main chamber is transformed in the inlet zone (II) and the outlet zone (IV) to a flow necessary for the sensing zone (III) of measuring reason, in which sensing zone (III) the fluid obtains a recordable velocity proportional to the volume flow which passes the device.

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**+ DESIGNATIONS OF “SU”**

Any designation of “SU” has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

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METHODS AND DEVICES FOR CONTROL OF FLUIDIC SYSTEMS

The present invention is related to a method and an apparatus according to the preamble of claims 1 and 10, respectively.

Laundry washing machines are known, which are controlled by electronic or electromechanical programmers provided with manual means for selection of the washing process parameters, determining the washing result and the operating cost. Usually, the washing process parameters, adjustable on the front panel of the washing machine, are made up of information about estimated laundry weight in dry condition, type of textile fabrics, degree of soiling and the rinsing and spin drying R.P.M., but also other information such as colour resistance, washing temperature and water hardness can be chosen in certain cases. The possibilities of manual pre-setting are usually limited to two or three optional selector positions for each parameter value. As a result of the manual pre-setting method great differences arise between conditions relevant in the real washing process, determining the wash result and the operating cost per weight unit, and the manually introduced parameter values, which attempt to describe an optimum washing process. Firstly, this is due to the fact that the wash goods, in process technical terms, only very roughly can be described by said manually pre-settable parameters and that several data determining to the washing result and operating costs are missing and, secondly, due to the fact that the pre-settable parameters can only be selected in intervals of character "little", "mean" and "much". Consequently, this means that a washing machine adjusted for laundering of whites has three pre-set process values 5, 3.8 and 2.5 kilograms relating to the wash load parameter. Thus, a pre-set error up to 250% is possible in the lower load range.

A further source of error will be added by the fact that the user of the washing machine can estimate only roughly the true values of the pre-set
parameters for wash goods in a particular laundering situation and its composition. The estimation of weight will be incorrect and the user can only pre-set the machine for one type of fabric whereas in the normal case the wash goods is composed of a mixing of different fabrics.

Washing machines are also known which are operated by manual pre-setting in accordance with the foregoing description and controlled by traditional pressure switches for loading water to necessary levels during the washing process. Consequently, these washing machines are impaired by errors of the above mentioned sources of errors and by volumetric filling errors related to the well-known weakness in regard to accuracy and reliability of washing machines controlled by pressure switches, as a limited number of filling levels (usually 2 or 3), sensitivity to vibrations (relative movements), influence of liquid absorbed by the wash goods etc. The volumetric errors in these known machines have been reduced by utilization of water meters for measurement of the liquid volume passing through the meter. Washing machine apparatus of these kind control the filling operation by using the pre-set parameter values of the washing process, introduced manually, for calculation of an optimum filling volume (represented by a digital reference value) according to empirical facts and national guiding bodies recommendations for best washing processes, which value is compared in the filling operation phase with the pulse number transmitted from the water meter (digital actual value), the water supply then being interrupted by the inlet valve at coinciding values.

Thus, control devices of this kind are impaired by the above errors which are reflected by the digital reference value.

Furthermore, devices of this kind are also known where, in addition, a second water meter has been installed measuring the amount of discharged water, the digital actual value of the control apparatus being corrected for the difference between calculated and measured quantity of discharged water. However, neither this correction means more than a marginal improvement and will only permit a correction of the total water balance afterwards i.e. for example only after that the washing cycle has been carried out and without knowledge of the liquid distribution, calculated on the basis of the liquid balance between the wash goods and the hydraulic volume of the washing machine, a relationship which is decisive to the process conditions in the subsequent filling operation of the washing cycle. Furthermore, devices of this kind are sensitive to functional troubles by the water meter installed in the discharge conduit being exposed to contaminated liquid containing sand, textile threads etc.
resulting in rapid wear of rotor bearings and risk of blocking the water meter rotor.

Known are also top-loaded washing machines with suspended or standing laundry container, where the load of the washing machine is determined by weighing by means of transducer elements of strain gauge type, whereby the weight of laundry is determined before wetting. Thereafter the dry laundry weight is utilized, with or without additional identification of the type of wash goods, by measurement of moment of inertia, together with manually pre-selected washing process parameters for optimizing the following washing process in accordance with the foregoing description. Washing machines of this kind are limited by the laundry container design forced upon them by the weighting method with respect to their use and design. They are also limited by a costly and vulnerable suspension and transducer arrangement, and they are expensive and complicated where it is necessary to use two separate measuring system for wash load identification.

Finally, dishwashers are known where the water filling operation is monitored by sensing the operation condition of the recirculation pump of the cleansing liquid circuit. At insufficient return flow of cleansing liquid to the recirculation pump supplementary water filling is undertaken, which ensures that damaging working conditions for the washing-up goods i.e. the food ware do not appear but results in increased energy and water consumption, irrespective of the quantity of food ware i.e. the dish load. Dishwashers equipped with this type of control means are lacking technique for carrying through a dishwasher programme, whose consumption and interrelated operating cost are adjusted according to the dishwasher load i.e. to utilize IEC place setting capacity in relation to the maximum capacity.

An object of present invention according to the first aspect of the invention is to provide a method and an apparatus for carrying the method into effect, implying control of a process for processing goods with at least one liquid, in order to obtain optimum control of the process. Usually, optimum process conditions means that the process is developed such by supervision and determining of one or more process parameter values, that the process is run through during the lowest operating cost and/or environmental stress for given desired process result. This is made possible according to the invention by introducing an initial, liquid-influenced analysis phase, preceding the conventional process, at least one parameter describing the amount of liquid bonded to (or removed from) the process goods being determined during the analysis phase. By said
parameter value or values being changed under control by changed analysis conditions, such as changed R.P.M. i.e. rotational speed, and by waiting for substantially stationary condition of wetting, the total liquid volume bonded to the process goods (during the analysis phase) as well as the amount of process goods can be determined. Thereby the bonded liquid volume can be expressed in units of volume and the amount of process goods in units corresponding to said parameter value or values, i.e. in units of weight, units of volume, units of surface etc.. On the basis of the total volume of liquid bonded to the process goods and/or the amount of process goods, the subsequent conventional process can be optimized.

Thus, in controlling a process for processing of goods with at least one liquid, the objects are attained by the invention obtaining the characteristics defined in claim 1.

An object of present invention is also to provide a method and apparatus for carrying the method into effect where said initial analysis phase is carried out during successively changed analysis conditions in intervals, such as successively increased or decreased rotational speed, implying that a series of analysis data (transducer information) are obtained, which allow in combination with the said parameter value or values unique to each type of process goods (part of the analysis), determination of the composition of the process goods, expressed in units according to the foregoing. By giving the invention the characteristics defined in claims 3 to 6, the said objects of the invention are attained.

A further object of present invention according to the first aspect of the invention is to provide a method and apparatus for carrying out the method, implying control of the conventional washing process in a commercial laundry equipment or in a domestic laundry washing machine in order to obtain an optimum washing result i.e. a desired washing result at the lowest operating cost and the lowest environmental stress. This is brought about according to the invention by introducing a liquid-influenced analysis phase before the conventional washing process, implying that the specific liquid content (accumulated liquid enclosed) in the wash goods in relation to the dry wash goods, henceforth called moisture ratio f, is changed in a controlled manner by changed analysis conditions, such as changed R.P.M. of the rotatable laundry container, and by awaiting that a substantially stationary liquid accumulation state i.e. wetting condition being established while simultaneously determining the quantity of liquid (volume) bonded or freed (removed) from the wash goods. Furthermore, it is an object of the invention to provide an
initial, liquid-influenced analysis phase in such way that parameter values (washing parameter values) decisive to the washing process are determined by measurement and at wetted condition of the wash goods and by a measurement method allowing description of mass transfer mechanisms basically related to diffusion and hydrodynamic convection, which during the conventional dispersed flow washing process are responsible for the fabric washing and rinsing results (the fabric cleaning process). By the law of fluid mechanic and physics of porous media it follows that at capillary equilibrium in the wetted wash goods bed, the textile material considered as a porous media, fluid mechanically can be characterized by two main concept, namely the permeability (flow through resistance) and the porosity, which both are described i.e. determined by means of the porous media saturation at prevailing capillary pressure, i.e. by the degree of liquid saturation or, converted, by the moisture ratio of the porous media. The latter values are in turn a function of the capillary pressure, which is controlled by external force fields such as the centrifugal force field generated by a rotating laundry container or by a rotating fluid volume.

From a process technical standpoint, i.e. from the aspect of washing and rinsing, it can also be shown that diffusion mechanisms appearing in a normal conventional fabric cleaning process can never be responsible alone for occurring transport mechanisms at acceptable processing time, but instead the dispersed hydrodynamic flow, and convective transport mechanisms in the textile pores in the wash goods generated thereof, is the dominating mechanisms, a dominance which, according to preceding description, is dependent on the permeability and porosity of the fabric. Thus, by experimentally establishing the unique relationship which prevails for each fabric geometrical design and type of yarn fiber for the moisture ratio as a function of the washing machine wash load (amount of wash goods) and the washing machine rotational speed i.e. the number of revolutions per time unit an unique parameter value is obtained, for example at absence of a fabric wetting flow, describing the hydrodynamic characteristics of the textile material which are decisive for the fabric cleaning process and the total amount of liquid enclosed in the wash goods.

The latter value can also be shown to be the fundamental washing process parameter value when optimizing of the washing process. Knowledge of the moisture value also gives information about of the wash goods weight in dry condition permitting description of, for example, the wash goods

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dimensions in the laundry container during the running fabric cleaning process.
Consequently, the objects to control a fabric cleaning process are attained by the invention exhibiting the characteristic features defined in claims 2.
An additional object of the invention is to carry through the initial analysis phase in such a way that the wash goods composition can be identified (when desirable) concerning wash goods consisting of various fabrics with different geometrical web or cloth design, i.e. yarn texture, dimensions and distance between yarn centers, which together with type of yarn fiber are designated the web or cloth structure, i.e. the wash goods structure.
By rotation of the laundry container and/or agitator (i.e. a fluid driver) with increasing or decreasing R.P.M. and by determination of the moisture ratio or its change before and after each change in the rotational speed, a series of measurement data are obtained, which allow, in combination with experimentally known moisture ratio values, in accordance with the foregoing description, of each type of wash goods covered by the analysis method, determination of the composition of the wash goods. Thus, the objects of controlling a washing process are obtained, by the invention obtaining the characteristics defined in claims 3 to 6.
Furthermore, an object of present invention according to the first aspect of the invention is to provide a method and an apparatus for carrying out the method, implying control of the conventional cleansing process in commercial washing-up equipment or in a domestic dishwasher in order to obtain an optimum cleansing result, i.e. a desired cleansing result at lowest operating cost and environmental stress. This is brought about in accordance with the invention by introducing a liquid influenced-analysis phase before the conventional cleansing process, implying that specific liquid binding to the food ware, expressed in volumetric units of liquid per surface unit of the food ware surface, henceforth called surface liquid binding factor, in a controlled manner is changed during the analysis phase from an initial condition, usually determined by the soiled food ware dry or not, to a substantially stationary wetting condition, with liquid film developed along the food ware. Since thus the thickness of liquid film developed at controlled wetting conditions is known for fluid mechanical reasons and is only slightly varying with the liquid wetting flow and the tilting of the food ware, the surface liquid binding factor is known, which means that this parameter value describes in this
manner the liquid volume adhering per surface unit to the surface of the food ware. By determining of the total liquid volume adhered to the food ware during the analysis phase and by knowing the value of the surface liquid binding factor, the actual load degree of the dishwasher can be determined, expressed in surface units or in standardized place settings (IEC), making it possible to optimize the following conventional washing-up process with regard to the actual dish load of the dishwasher. Thus, the objects of controlling a cleansing process are the invention obtaining the characteristics defined in claims 7 and 12.

The present invention will now be explained in the following description in non-limitative examplifying purpose with reference to the accompanying drawings which show:

Fig. 1: control apparatus - block diagram
Fig. 2: an analysis step - basic figure
Fig. 3: parameter value p as a function of state of analysis
Fig. 4: the moisture ratio \( f_c \) as a function of state of analysis - laundry container R.P.M.
Fig. 5: liquid contents of the wash goods - basic figure
Fig. 6: distribution of wash goods at different laundry container R.P.M.
Fig. 7: washing machine - direct moisture ratio control
Fig. 8: washing machine - indirect moisture ratio control
Fig. 9: washing machine - direct moisture ratio control
Fig. 10: washing machine - indirect moisture ratio control at analysis of the wash goods composition
Fig. 11: washing machine - agitator design
Fig. 12: measurement signal as a function of the load of the washing machine
Fig. 13: moisture ratio as a function of load of the washing machine
Fig. 14: moisture ratio as a function of load of the washing machine - instantaneous and stationary value
Fig. 15: moisture ratio as a function of electrical resistance and filling volume of liquid
Fig. 16: dishwasher - operationally adapted to dish load
Fig. 17: collecting liquid volume - dishwasher
Fig. 18: collecting liquid volume. Optical sensor means
Fig. 19: cleaning means for the fine mesh strainer - dishwasher
Fig. 20: load degree of the dishwasher as a function of the liquid volume adhered to the food ware
Fig. 21: dishwasher - fixed liquid pouring system - front
Fig. 22: dishwasher - fixed liquid pouring system - side view
Fig. 23: spraying arms with nozzles - end view
Fig. 24: spraying arms with nozzles
Fig. 25: dishwasher - pressure distribution of the wash chamber
Fig. 26: valve arrangement - central part of spraying arms - axial section
Fig. 27: valve arrangement - central part of spraying arms - top view
Fig. 28: control and monitoring system. Optical link with optical sensors and transducers for fluid flow
Fig. 29: optical link according to fig. 28. Basic figure of principle components
Fig. 30: signal levels of optical link according to fig. 29
Fig. 31: parameter value of the combined signal. Pulse width and limit values
Fig. 32: signal levels. Combined signal at partially blocking of the light transmission passing sensor means $S_{11}$.
Fig. 33: signal levels. Combined signal at sensor means operating with continuously and discrete signals
Fig. 34: controlling and monitoring system for household machines
Fig. 35: controlling and monitoring system for household machines. Component operating with flow regulation with simultaneous measurement of the regulated flow and deblocked light transmission in rest position of sensors and component
Fig. 36: designs of sensors operating according to different principles.
Fig. 37: controlling and monitoring system for washing machines
Fig. 38: sensor means for measurement of degree of contamination in flows
Fig. 39: sensor means for monitoring of process temperature
Fig. 40: optical link according to fig. 35. Supervision of leakage in household machines - internally.
Fig. 41: optical link according to fig. 35. Supervision of leakage in household machines - internally and externally
Fig. 42: optical link according to fig. 35. Supervision of leakage. External installation of the component
Fig. 43: flow throttling-measuring device(component) - Schematic outline of the operating principle of the component
Fig. 44: component - basic figure of a radial section of zone I, II, III and IV
Fig. 45: component - axial section of zone I
Fig. 46: component - basic figure of an axial section of zone II, III, IV
and V

Fig.47: component - radial section of zone IV and V

Fig.48: component - radial section of zone IV

Fig.49: component - basic figure of an axial section of zone II, III, IV and V

Fig.50: instrument constant and volume flow rate as a function of inlet pressure

Fig.51: component design - one outlet. Axial section

Fig.52: component according to fig.51. Radial section of zone II and V

Fig.53: component according to fig.51. Rolling contact surfaces arranged for a sensing element - ball

Fig.54: component according to fig.51. Magnification of diaphragm

Fig.55: component according to fig.51. Different position of sensing element in shape of rotor, roller or ball

Fig.56: component - 3 outlets with division 120°. Axial section

Fig.57: component according to fig.56. View according to D-D in fig.56 at excluding bodies of revolution

Fig.58: component - 3 outlets with division 120°. Axial section. Outwardly radial flow

Fig.59: component according to fig.58 showing outlet zone IV and valve seats according to section F-F in fig.58.

Fig.60: component according to fig.58. View according to E-E in fig.58

Fig.61: component - 2 outlets. Alternative design of zone II and III

Fig.62: component according to fig.61. Radial section of zone III

Fig.63: component according to fig.61. Radial section of zone IV and V

Fig.64: component axial section of zone IV and V. Separately axial tube forming zone IV.

Fig.65: component - 2 main chambers and 3 outlets. Axial section through main chamber 1 and 2

Fig.66: component according to figure 65. View.

Fig.67: component - 1 outlet - provided with electromagnetically operated safety valve of membrane design. External installation with pressure-free inlet hose and supervision of leakage

Fig.68: component according to fig.67. View.

Fig.69: component according to fig.67. Radial section of hosing and cables arrangement

Fig.70: component - 1 outlet - provided with pressure controlled safety valve of membrane design. Permanent-magnetic switching force.

Fig.71: component - 1 outlet - provided with pressure controlled safety
valve of membrane design. Switching force by ball controlled by gravity force.

Fig. 72: component - 1 outlet. Manually operated valve.

Figure 1 shows a process goods container, 1 with process goods 2. The process goods are exposed to a liquid influence by a flow 3, regulated by flow regulating means 4 and preferably volumetrically determined by a quantity metering means 5. Sensor means 6 is sensing a process parameter value or values describing the amount of liquid bonded to the process goods and emit one or several control signals to control unit 8, which also emits and receives the necessary measuring signals 9 and pilot signals 10 to the quantity metering means 5 and to the flow regulating means 4. The control unit can operate electronically and/or electromechanically as well as in a hydraulic/pneumatic mode in different hybrid arrangements where signals occurring are conditioned and processed or not depending on the type of application for control apparatus.

The basic operations designated 4, 5, 6 and 8 of the control apparatus are exercised by devices of a design known per se. Thus, the quantity metering means consists of a transducer of conventional design for determining mass, volume or flow rate. The flow regulating means comprises devices known in the art for regulating or shutting off a flow, such as control regulating and stop valves. Here the term "flow" means fluid transport expressed as liquid amount per time unit.

The sensor means is composed of sensor devices of conventional type for sensing or measuring of physical magnitudes or states, such as pressure, liquid level, moisture and concentration. For measuring or detecting these values a number of known sensors are available which operate according to well-known principles, and each one can be used optionally for the sensor means component of the control apparatus. Finally, the control unit comprises one or several means of known type for emitting, receiving and processing of signals of any type in correspondence with the means 4, 5 and 6 of the control apparatus. "Processing" means calculation operations, carried out while using technique known per se, for control of processes and communication with internal or external computer units. In the processing concept also a straightforward signal transmission can be included with or without signal conditioning or amplifying of the signal.

An initial, liquid-influenced analysis step in accordance with figure 2, implying a changed process condition can be described by the relations
\[(q_1 - q_2) \Delta t = \Delta V = \frac{N_x}{K_R} - V_1 = Z (p^{i+1} - p^i)\]

where

- \(Z\): designates the amount of process goods participating in the process and unknown at the start of the process.
- \(\Delta V\): designates the amount of liquid bonded to the process goods.
- \(p^i\): designates the parameter value \(p^i\) at analysis step \((i)\), defining the state of the analysis. The parameter value \(p^i\) is a specific value expressing a process goods property, determining to the process, specified per unit of the process goods, such as property per surface unit, volume unit or weight unit etc.. The value is determined by sensors by direct or indirect measurement.
- \(C\): sensors of above specified type for sensing the parameter value \(p^i\) (designated \(S_2\) and \(S_3\) and \(S_4\) in figure land 2, respectively.
- \(q\): designates liquid per time unit supplied to and/or drained off from the process goods.
- \(\Delta t\): designates the time period of an analysis step.
- \(N_x\): designates the value of the signal from the quantity metering means when the predetermined parameter value \(p^{i+1}\) is reached.
- \(V_1\): designates the excess liquid which is not bonded to the process goods during time period \(t\).
- \(K_R\): designates the instrument calibration constant of the quantity metering means.

At reaching a predetermined parameter value \((p^{i+1})\), sensed by sensor means \(6\), the influence on the process goods \(2\) by the process liquid, measured by the quantity metering means \(5\), is changed or interrupted by the flow regulating means, changing their adjustment or closing or by otherwise changed process conditions, for example, by a changed R.P.M. in the case of a rotatable process goods container. This occurs by the control unit \(8\) receiving control signals \(7\) as well as emitting pilot signals or other signals \(12\).

Thus, by following the transformation, determined by parameter \(p\) of the condition of the process goods, under the influence of the process liquid \(q\), two values decisive to the progress of the process can be determined in conformity with the given mathematical relationships, on the one hand, the amount of process liquid bonded to the process goods, on the other, the amount of process goods participating in the process.
By repeating, as illustrated in figure 3, the analysis step as described
above, the possibility also opens to establish a third value decisive to
the progress of the process, namely the composition of the process goods
with regard to the parameter p. Neither is the process limited to only one
parameter value, but can in an analogous manner include several param-
eters.

From the mathematical relationship and figure 2 it can be seen that if the
inflow q₁ is stopped, conditions otherwise the same, the parameter value p
will be reduced during the analysis step, a circumstance which corresponds
to, for example, a step p³ to p⁴ in figure 3, and which according to the
method is utilized in practice for determination of the process goods
composition.

Thus, by letting the described analysis phase constitute an introduction
phase preceding a conventional process, such as a wash or cleansing
process, the load of the machine can be decided before the conventional
process, and the process procedure can be optimized with respect to the
machine load. In view of the difficulties for a user of such machines to
estimate correctly the amount of wash goods and its composition, or the
amount of washing-up goods (food ware), this everyday problem has been
chosen in order to examplify the advantage of the invention.

A condition decisive to the washing result of a washing process is the
chemical and the hydrodynamical interaction between the washing liquid and
wash goods. By examining the influence of different washing process
parameters on the washing result it can be shown that one of the
fundamental parameters determining optimum such result is knowledge of
the washing liquid volume enclosed in the wash goods by capillary and
mechanical influence. Thus, a decisive fact in the control of a washing
process in order to obtain optimum process conditions is knowledge of the
liquid contents of the wash goods, preferably expressed by the moisture
ratio, which defines the relationship between the weight of the washing
liquid enclosed in the wash goods and the dry weight of the wash goods,
i.e. washing liquid weight per unit of the dry goods. Knowing the exact
measurement value of the volume of washing liquid enclosed in the wash
goods in a controlled manner, in an initial analysis phase, the optimum
liquid filling operations and the optimum dosing operations of the optimum
washing process can be carried out, also here by exact measuring of the
supplied volumes or the supplied amounts and then taking into account the
liquid supplied in the initial analysis phase.
Thus, generally expressed the fundamental principle of the invention implies, according to the first aspect of the invention, that the decisive question, i.e. the parameter value necessary to be able to determine the optimum process conditions (e.g. for dishwashers and laundry washing machines), is knowledge about the amount or volume of process liquid (washing- and cleansing liquid) which, per length-, surface-, volume- or weight unit of the unprocessed goods or totally (e.g. dry wash goods or food ware) and during controlled conditions (homogeneous wetting and volumetric measurement of the process liquid) by adhesion, film formation, liquid accumulation or chemical interaction, are bonded to the process goods during the controlled, changing phase (the wetting phase). This knowledge is utilized together with quantity measurement of supplied process liquid to determine process liquid bonded to the process goods and/or total amount or volume or composition of the process goods, participating in the process, and to control and interrupt the transformation of the process during influence of process liquid (i.e. the wetting phase) at an attained, predetermined parameter value.

In the washing process example this implies filling of a liquid during volume measurement and control of one for the process decisive parameter value, i.e. the moisture ratio. At attained moisture ratio value the filling progress is interrupted. This is carried out in a first, initial analysis phase, which precedes and is determining to the conditions in the following washing process.

The analysis phase is also causing the advantage of washing performance by reduced textile wear, by the fact that the wash goods is given a rapid, homogeneous and controlled wetting.

In principle, the washing machines controlled according to the method of the invention can be designed in different ways depending on whether the control apparatus carried out in accordance with the method is adapted to direct or indirect moisture ratio control. In this respect direct moisture control refers to such design, where a measurement signal is created proportional to the moisture ratio of the wash goods.

Schematically figure 7 and 8 show two cases where the wash goods is wetted by a liquid which is supplied to the laundry container substantially radially and substantially diametrically, respectively, and where the liquid can be internally and externally recirculated or not to the wash goods. The wash goods is homogeneously wetted, preferably during movement of the wash load, and the liquid supply is monitored and controlled by the moisture ratio of the wash goods, which is determined at least at the end.
of the filling procedure, where a predetermined value is causing interruption of the liquid supply. Externally supplied liquid volume is determined by a component having a quantity metering functioning. With respect to the procedure for moisture ratio measurement, different choice of main direction of the wetting flow can exist, implying the washing machine design is carried out in different ways.

Hence, figure 7 represents the case where one or more moisture sensors are located inside the laundry container of a washing machine, i.e. in the tube, said sensor or sensors emitting by direct contact with the wash goods a control signal to the control unit 32 during a first phase preceding the different operating cycles of the washing programme.

Figure 9 illustrates the case where one or more moisture sensors are located on the outside of the laundry container of a washing machine, said sensor or sensors then sensing the moisture in the space of the gap outside the laundry container and thus also, indirectly, the moisture ratio of the wash goods and emitting a control signal to control unit 17 during the wetting procedure i.e. during a first phase, the analysis phase, foregoing the different operating cycles of the washing programmes.

On the other hand, if the washing machine designer wants to utilize the invention in combination with indirect moisture control or moisture measurement, the structure of the washing machine can be according to the principle figure 8. In this case the wash goods is wetted, in the same way as earlier has been described, by liquid which can be, internally and externally the laundry container or tube, recirculated or not, the quantity of the externally, supplied liquid being measured during the analysis phase by a component having a quantity metering function.

The excess liquid, i.e. liquid that is not by capillarly or mechanically influence bonded to the wash goods, is collected in a collecting liquid volume \( V_1 \), 43, determined by the sensors \( S_2 \), 45 and \( S_3 \), 44, said collecting liquid volume then being so dimensioned in combination with the capacity of a possible recirculation system that the collecting liquid volume is filled to the sensing section of sensor \( S_2 \), at first when the wash goods has reached the desired, predetermined and stationary moisture ratio. When so happens the external liquid supply is interrupted.

The hydraulic system of the washing machine contains, calculated from the beginning of the analysis phase and after the controlled wetting phase has been carried out and irrespective of whether direct or indirect moisture measurement has been employed, on the one hand, a liquid volume \( \Delta V_L \) by capillarly and mechanically influence bonded to the laundry and
corresponding to the optional predetermined moisture ratio and, on the other hand, a liquid volume equal to the known excess liquid volume or the collected liquid volume $V_L$.

Exemplifying devices according to figures 7, 8 and 9 are all included in the method according to the invention and can be commonly described in the following.

By supplying a liquid to the wash goods in a strictly controlled manner, the moisture ratio $f$, here defined according to

$$f = \frac{M_{LW}}{M_{LD}} = 1 + \frac{\mathcal{S} \cdot V_L}{M_{LD}}$$

where $f$ will be changed from an initial value $f_0$ to a controlled predetermined, stationary, final value $f_c$.

$M_{LD}$: designates the weight of the wash goods in dry condition (kg)

$M_{LW}$: designates the weight of the wash goods in wet condition (kg)

$V_L$: designates liquid volume by capillary and mechanically influence bonded to the laundry ($m^3$)

$\mathcal{S}$: designates the density of the liquid (kg/m$^3$)

In other words, the moisture ratio of the wash goods is changed in reversed order compared to the operating manner of a tumbler dryer.

The compounded or weighted moisture ratio, of the wash goods in the laundry container can be controlled and influenced by several parameters:

-- the wetting system, i.e. primarily by the flow rate of the supplied liquid, the nozzle design and the nozzle location in relation to the distribution of wash goods in the laundry container

-- the movement scheme of the laundry container and the fluid drivers such as the agitator or the pulsator of the washing machine, i.e. of the number of revolutions per time unit, the direction of rotation (i.e. the angles of agitation), reversing arrangement, continuously or intermittent operation and of the mechanical design and dimension of the laundry container

-- the recirculation system, if applicable, i.e. of the flow rate of the recirculation flow, internal or external recirculation in relation to the laundry container or tube, continuous, periodical or delayed recirculation during the analysis phase, mechanical pumping or ejector pumping (e.g. jet pumping driven by the external flow).

By choosing different parameter values, according to the above, the liquid flows occurring in the exemplified washing machine designs in figures 7, 8 and 9 can be determined by experimental tests. Thus, by changing some of
the above listed parameters the actual liquid flows can also be influenced in a desired way, so that from a measurement point of view best fluid mechanical condition is obtained. By varying, as an intellectual experiment, the supplied flow (to a given wash goods at a given number of revolutions) which is composed of a given flow rate from the wetting system and/or recirculation system, from a high value to the value zero it is realized that different fluid mechanical conditions arise. These different flow conditions can each be utilized according to the invention for an analysis procedure. However, in order to simplify the description this is concentrated to two cases suitable from the measurement point of view, namely wetting (i.e. increased moisture ratio) within a suitably selected revolutions-per-minute range (R.P.M. interval) and "dewatering" (i.e. desaturation at reduced moisture ratio) in the absence of wetting flow to the wash goods, suitably wetted in an earlier stage of the analysis phase within a suitably selected revolutions-per-minute range (R.P.M. interval). Determining for the moisture of the wash goods is, in all said cases, in a given moment counted from the beginning of the analysis phase, for a given amount of laundry and for a given R.P.M. value, the balance between liquid (i.e. liquid volume) supplied to and drained off from the wash goods.

The supplied liquid can be controlled by externally supplied liquid flow rate and by recirculated flow rate, if applicable. The liquid flow drained off from the wash goods can be controlled by the distribution of the supplied liquid and by the pressure gradients generated in the wash goods, created by the radial acceleration (centrifugal force field) and by, if applicable, the hydraulic head (gravitation forces field), the flow being determined by the permeability of the wash goods (flow through resistance) i.e. by factors such as type of wash goods, wash load distribution, periodical redistribution of the wash load and the liquid accumulation capacity of the wash goods by capillary and mechanical binding effects.

The latter values, thereby to some extent dependent of the packing degree of the wash goods, i.e. by textile compression and possibly existing larger cavity formations. In this context wash goods means one or several textile wares (articles) where each textile ware is determined by type of fiber utilized and geometrical design of the fabric. An instantaneous condition of equilibrium prevails when the supplied liquid volume is equal to the sum of the change in liquid volume bonded in the wash goods by capillary and mechanical influence and liquid volume drained off from the wash goods, all values counted per unit time. The instantaneous state of equilibrium
admits that a relationship between the amount of wash goods, determined in dry condition and the instantaneous value of moisture ratio $f_m$ can be established. As a matter of principle, a relationship is obtained according to figure 14, where consequently the shape of the curve and its position can be changed by change of the design parameters mentioned earlier.

Accordingly a stationary state of equilibrium, at a given number of revolutions per time unit, corresponding to an unchanged moisture ratio $f_{c_n}$ is determined by an unchanged liquid volume bonded in the wash goods by capillary and mechanical influence and is reflected in the design according to figure 8 by the liquid level in the collecting liquid volume $V_1$ remaining on a constant level at shut-off, external supply flow. This implies also that when the increase of the volume of liquid bonded per time unit by capillary and mechanical influence during a wetting procedure with increasing $f$-value, decreases and goes towards value zero, the liquid level in collecting liquid volume $V_1$ is increased when external supply flow is turned on. For suitably chosen values of volume $V_1$ and a suitably chosen external flow rate turned on, the liquid level will reach the $S_2$-level 45, according to figure 8, only when, according to the foregoing description the desired moisture ratio controlled by chosen parameter values has been established in the wash goods, i.e. when a stationary, predetermined state of equilibrium prevail. Consequently, this implies that, by measurement of supplied liquid and by knowledge of the size of the volume $V_1$, defined by the sensors $S_2$ and $S_3$, according to the invention, a predetermined, stationary moisture ratio curve according to figure 14 can be established as a function of the amount of dry wash goods for a given washing machine design and for each value of the number of revolutions.

This can be carried out in accordance with the following test or calibration procedure applied by the machine manufacturer.

1 Choose representative cloth (textile ware) for the class of textiles (textile wares) which will be included in the procedure. (Here, the international classification system may provide the reference).

2 Choose the first point for the $f_{c_n} - M_{LD}$ curve which will be determined i.e. choose $M_{LD} - f_0$ value.

3 Determine by weighing $M_{LD}$ and $f_0$ (thereby the initial moisture ratio $f_0$ is determined in relation to prevailing air humidity).

4 Load the washing machine, provided with the control apparatus according to the invention, with the test goods and start up the procedure from the
condition $f_0$. The drum of the washing machine (in the case of drum machines) will thereby rotate at a given R.P.M value in the end of the analysis phase determined by the control apparatus.

5 Change the moisture ratio of the test goods according to pre-programmed sequencing of the analysis phase and wait for stationary wetting conditions. Does the analysis phase comprise wetting in one step with indirect moisture ratio measurement, the inlet valve will be closed by the sensor $S_1$ when stability has occurred.

6 The pulse number $N_x$ received from the quantity measurement of the control apparatus is stored at obtained wetting conditions corresponding to supplied or drained off liquid volume during the analysis phase.

7 Evaluate according to

$$\frac{N_x}{K_R} - V_1 = M_{LD} \left( f_{cal.1}^{\text{cal.1}} f_0 \right)$$

The instrument calibration constant $K_R$ and the volume $V_1$ are known so why $f_{cal.1}$ can be calculated.

8 Repeat the procedure until the desired curve is obtained.

By this test or calibrating procedure used during the design and development work of the machine, the $f_c$-values are obtained which by pre-programming is utilized by the machine user during the analysis phase at the normal operating condition of the machine when instead the amount of the wash goods $M_{LD}$ is unknown before the analysis phase.

Generally viewed, it is realized that at well-adapted external supply flow according to previous description as well as at recirculation or pre-wetting with following analysis phase performed at shut-off external supply flow and during increase of the speed of rotation, sensor controlled filling can be carried out to level $S_2$, according to figure 8 during measurement of supplied liquid. In the latter case by after-filling to the $S_2$-level by direct filling into the $V_1$-volume.

In an analogue way it is also realized at reduced moisture ratio, by increase of the speed of rotation after an initial wetting, that a removed liquid volume can be determined correspondingly by draining to $S_2$- or $S_1$-level during simultaneous volume measurement.

Consequently, a wetting or desaturation ("dewatering") procedure of the above kind implies that the moisture ratio increases or decreases, respectively, from a first state or condition to a second state or condition in the way illustrated by the curve 18 (increase) and 19 (decrease) in figure 4.
The moisture ratio curves, which have been established in the way indicated for different textiles, are dependent on aforesaid described design parameters and the absolute value of the moisture ratio can be strongly influenced, for example, by the R.P.M. value of the laundry container, but the moisture ratio values, according to the curves, are completely repeatable for the same type of wash goods at otherwise unchanged values of the design parameters.

This is explained by the fact that the structure of the textile material or fabric, forms an unique pore size distribution function for each type of textile material or fabric (e.g. cloths or webs), i.e. distribution of cavities such as capillaries, whereby the structure of the textile material or fabric is determined by the mutual distance of the yarns (i.e. the threads) and by the individual yarn texture (defining together the geometrical design of the textile ware) and by the type of fibers. Consequently, at the same capillary pressure determined by the number of revolutions per time unit of the laundry container (e.g. at absence of wetting flow), each particular textile structure (e.g. cotton sheets, terry cloth, polyester, mono or bipoorous fiber etc.) will in a unique way bond or enclose liquid in the wash goods in the laundry container during rotation and be the cause of a unique \( f_c \)-curve in relation to the amount of wash goods and number of revolutions per time unit.

At the practical design work, such design data are chosen which bring with them that the dynamic and hydrodynamic properties of the wash goods are utilized in the best way for the washing process. If recirculation occurs, this can advantageously take place in a delayed pump sequence, counted from the beginning of the analysis phase in order to avoid longer period with air-liquid mixture. To attain a maximum of repeatability in the value of the moisture ratio, according to the figure 14 the wetting procedure is carried out such that homogeneous wetting of all the kind and parts of the wash goods is arising. This will be facilitated by alteration of the direction of rotation of the laundry container during the analysis phase. Depending on chosen R.P.M. value for the rotating laundry container, which also is leading to different distribution of the wash goods in the container, suitable location and design of the liquid nozzle head is chosen. Figures 6a and 6b show in principle different cases relating to low and high values of rotational speed, where the liquid flow drained off from the laundry container is forced to move in a substantially radial transport direction at the higher R.P.M. value. At the lower R.P.M. value of the laundry container, and at wetting during th
analysis phase there is obtained a high moisture ratio value in the stationary, final state, corresponding to that when the liquid level reaches the sensing level $S_2$, as explained in the foregoing. This movement scheme for the laundry container, i.e. one analysis step carried out at one and a low final R.P.M. value during the analysis phase, can be chosen when the designer's goal is to carry out wash load accommodation of the washing machine process by optimizing the process in respect of washing liquid volume $\Delta V_L$ bonded to the wash goods and in accordance therewith realize the savings in operation cost, disregarding the influence of the wash goods weight or wash goods composition on the process result. At a higher value of the R.P.M. of the laundry container during the analysis phase a lower value of moisture ratio $f_c^*$ is obtained in the stationary, final state. Examples of experimental $f_c^*$ values at abscence of wetting flow are revealed in the following table.

<table>
<thead>
<tr>
<th>Laundry container design</th>
<th>Terry cloths $f_c^*$</th>
<th>Sheetings cotton $f_c^*$</th>
<th>Polyester/ cotton $f_c^*$</th>
<th>Number of revolutions R.P.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1.59</td>
<td>1.59</td>
<td>1.61</td>
<td>970</td>
</tr>
<tr>
<td>II</td>
<td>1.77</td>
<td>1.67</td>
<td>1.57</td>
<td>790</td>
</tr>
<tr>
<td>III</td>
<td>2.28</td>
<td>1.83</td>
<td>1.75</td>
<td>460</td>
</tr>
<tr>
<td>IV</td>
<td>2.98</td>
<td>2.02</td>
<td>2.06</td>
<td>305</td>
</tr>
</tbody>
</table>

By choosing a high R.P.M. value for the laundry container a constant $f_c^*$ value can be maintained for different textile fabrics (terry cloth, cotton, polyester) and this with high accuracy. If so is desired also different R.P.M. value be can chosen (coordinated with the washing programme division) so that the R.P.M. in the analysis phase for whites and coloured fabrics (cotton/ terry cloth) is chosen high, while a lower R.P.M. value is chosen for synthetic fabric (cotton /polyester). Also in this way the $f_c^*$ -value of the respective selected programme will be constant and independent of the mixture of textile fibers in the wash load (pure cotton or cotton/polyester mixture).

Consequently, a pre-programmed wash goods choice gives in combination with a movement scheme of the laundry container during the analysis step, corresponding to one and a high final R.P.M. value of where this R.P.M. value is selected with regard to type of textile fabrics, a nearly constant f-value also for a mixture of textile fabrics (textile ware) and thereby information about $\Delta V_L$ as well as $M_{LD}$, i.e. the weight of the wash
goods based on the weighted moisture ratio. (Thereby $\Delta V_L$ designates the liquid volume bonded to the wash goods according to page 25). If instead, tested f-curves for different textile fabrics in a corresponding way to previous description are utilized to determine the liquid content of the wash goods $\Delta V_L$ and the weight composition $M_{L1'}$, $M_{L2'}$, ..., and textile structure data (type of fibers, yarn texture and yarn mutual distance i.e. terry cloth, cotton sheet, polyester cloth etc.) where $M_{L1'}$, $M_{L2'}$, ..., designate the dry weight of respective type of textile fabrics (textile ware), unique moisture ratio curves for each textile will be established on the basis of experimental data, for example, by a calibrating procedure. Starting from these moisture ratio curves and by a movement scheme of the laundry container of the wash goods during the analysis phase corresponding to several successive analysis step at increased or decreased R.P.M. value i.e. decreasing or increasing moisture ratio values, respectively, a series of relationship can be established forming a system of equations describing the liquid volume bonded to the respective type of wash goods as well as the total and measurable liquid volume balancing said first mentioned partial liquid volumes. Partial volumes bonded in the mixed wash goods and the changes in total volume which arise at a changed analysis R.P.M. is illustrated in figure 5, where $\delta_1$, $\delta_2$, ... designate removed or bonded liquid volume at changed R.P.M. By a known manner calculating the values $M_{L1'}$, $M_{L2'}$, ... with utilizing the calculation unit of the washing machine and measured volumes during the analysis phase, information on the weight composition as well as the textile structures are obtained, i.e. also type of fibers. Finally, the indirect method can be modified in respect of the design of the conventional washing machine. In case the washing machine is provided with a mechanical shut-off valve at the connection point of the bellows of the discharge conduit arrangements to the laundry liquid container (46 according to figure 8), the analysis phase can be started up by soaking-through the wash goods in the laundry container while measuring liquid quantity supplied by keeping the mechanical valve closed. After that, the valve is opened and the laundry container is rotated as previously described, in order to obtain the wash goods moisture ratio prescribed. In this process the free liquid in the liquid container is drained to the collecting liquid volume $V_1$, and after-filling is made during the volume measurement until the liquid level reaches the sensor level $S_2$, the
external flow being interrupted as described earlier. By the volume measurement and knowledge of the size of the collecting liquid volume $V_1$, a value of the liquid volume enclosed in the wash goods is obtained also in this case.

In the case when direct moisture ratio control or measurement takes place by means of a moisture sensors operating according to known principles or by some other sensor functioning dependent of the wash goods moisture ratio, it is advantageous with a multitude of fine droplets, well-dispersed in the spray supply of the liquid. By a "fog similar" distribution of liquid droplets a homogeneous wetting of the wash goods is achieved, without local accumulations of free liquid volumes. As the initial phase in agreement with the previous description only constitutes analysis phase for determining the wash load conditions of the washing machine, e.g. the amount and/or type of wash goods, the alteration range in the moisture ratio, from the initial state $f_0$ to the predetermined state $f_C$, where the liquid supply is interrupted, can also be made small, which is advantageous with regard to the way of operating of the moisture sensors known in the art.

Generally seen, at internal moisture sensor location according to figure 7, the accessibility of a direct measuring signal imply, when utilizing resistive moisture sensing according to known principles for tumble dryers, that a respective voltage or resistance value $U$ and $R$ corresponding to the $f$-value, i.e. the specific liquid bonding of the wash goods, can be monitored as a function of the filling volume, determined by the quantity metering means and designated $V_x$, with regard to the amount of wash load unknown in the initial moment. This volume value $V_x$ will thus reflect the wetting degree of the wash goods, and a relationship according to figure 15 can be established by test. That so is the case, is also realized by the fact, that the known resistive measurement technique implies that the resistance against the passage of electrical current of the network of liquid filled cavities (corresponding to the wetting degree of the wash goods or to the moisture ratio at prevailing capillary pressure i.e. R.P.M.value) is measured, whereby the degree of filling of the pores or voids of the wash load and its interconnected tortuous paths determine the resistivity value. When stationary relations have been attained the wash goods has, at chosen design parameter values, bonded a maximum liquid volume $\Delta V_L$ at current amount of wash goods and R.P.M. value according to foregoing description, which means that the change in the moisture ratio with changed filling volume $V_x$ (i.e. at efforts to
increased wetting) decreases and goes to zero, i.e. a stationary condition sets in.

Different signal interrupt conditions for the liquid supply can be laid down, outgoing from the relation according to figure 15, the above mentioned forming a possibility to define by measurement techniques the stationary wetting condition of the wash goods.

By improving the measuring techniques for the moisture ratio and its measuring signal, the influence on the signal interrupt condition from the amount of wash goods and the type of wash goods, can be reduced.

Due to the fact that the measuring signal (i.e. the resistance or the voltage value) is influenced by the random distribution of different pieces of wash goods compared to the sensors of the laundry container, suitably a signal processing in the form of mean value formation can be carried out, for example, by establishing a moving mean value during the wetting procedure, which can be done easily by means of microcomputer technique. Hereby, the mean value is formed by a number of measurements during a sampling period, where the latest formed mean values during successive sampling periods are stored, these values being carriers of information about how the wetting condition of the wash goods has been changed. Instead of interrupt conditions according to the above, if desired, information about the speed with which the wetting procedure is continuing for given supplied liquid volume (for example per decilitre) at suitably chosen sampling conditions, can constitute interrupt conditions for the liquid supply, implying that further liquid volume necessary to finally obtain the stationary \( f_C \)-value at the end of the analysis phase can be established and filled by control of the \( N_X \)-signal.

Consequently, the working range of the moisture sensor does not need to be extended to the stationary \( f_C \)-value but the interrupt conditions can be established by extrapolation of the wetting curve. If a moisture sensor of resistive type is chosen, working according to known relationship between the specific electrical resistivity or conductivity of the wash load and its moisture ratio \( f \) (or residue moisture ratio if compared with the tumbler dryer technique) a technical solution is also obtained which is specially advantageous in cases where washing and drying processing are combined in one and the same machine, because the sensor system can be used both for controlled wetting and controlled drying.

If the washing machine is designed according to figure 9, i.e. with external sensor location in relation to the laundry container, a direct sensor signal exists also in this case, corresponding to the moisture
ratio of the wash load. An great advantage with this design is the circumstance that the sensor can be assembled in the wall of the stationary container projecting or not into the annular gap between the washing liquid container and the laundry container. With this location the sensor will be influenced by the liquid contents in the air stream created in the annular space, which in turn is depending on the moisture ratio of the wash goods. That this is the fact depends partly on the two-phase dependent transport of the liquid molecules from the wetted wash goods to the surroundings, partly on the fact that the free liquid drops on the outside of the laundry container wall or the drops leaving the outside wall of the laundry container are exposed to evaporation caused by the air flowing in the annular gap. Because of incomplete evaporation of the free liquid drops the wetting of the inside of the container can be used for control of the moisture ratio of the wash goods. The fluid film on the inside of the washing liquid container will increases as soon as a maximum of wetting \( \Delta V_L \) corresponding the \( f_c \) - value has been obtained and the liquid flow penetration begins. The resulting liquid accumulation can be used for activation of one or several sensors of known design, as resistive or capacitive such. Consequently, in this case the interrupt or control condition relating to the external liquid supply, corresponding to stationary wetting conditions will be determined in relation to the presence of liquid in annular gap. At a strong increase of accumulated liquid for a given value of supplied liquid volume \( V_x \) the stationary \( f_c \) - value has been reached for the wash goods implying that the external liquid supply is interrupted.

In the above manner established moisture ratio during controlled wetting conditions determines the dry weight of the wash goods. At a given R.P.M. value the following relationship is valid

\[
S \cdot V_L = M_{LD} (f_c - 1)
\]

Regarding, that the moisture ratio is varying with \( M_{LD} \) according to figure 14 i.e. \( f_c = F(M_{LD}) \) where \( F(\quad) \) designates the mathematical function determined according to the above mentioned calibrating procedure and the fact that the analysis phase takes place from a first state (condition) to a second state (condition), the change of liquid bonded or enclosed in the wash goods will be determined, which means the above given relation can also be expressed
\[ \Delta V_L = \frac{M_{LD}}{3} F(M_{LD}) \left( 1 - \frac{f_0}{F(M_{LD})} \right) \]

where \( \Delta V_L \) designates the change of capillarily and mechanically influenced liquid volume enclosed in the wash goods \( M_{LD} \) at a given number of revolutions per time unit, and \( f_c \) designates the moisture ratio at stationary condition and \( f_0 \) the moisture ratio of initial condition.

The filling volume arisen during the analysis (designated \( V_x \) with respect to unknown amount of wash goods in the initial moment) creates the measuring signal \( N_x \), generated by the quantity metering component (the means 5 according to figure 1) in conformity with the expression

\[ N_x = K_R V_x = \left( \Delta V_L + V_1 \right) K_R \]

where \( K_R \) is the instrument calibration constant of the quantity metering component and \( V_1 \) the collecting liquid volume according to the foregoing (in the expression also a correction term can be included corresponding to the liquid adhesion occurring, air-born liquid and other volumes of tubes if these volumes are of importance).

The collecting liquid volume \( V_1 \) is known by the design of the washing machine and by the sensors of the control apparatus and can assume the value zero when fine droplets in a well-dispersed wetting procedure are present.

Thus, the \( N_x \) - signal constitutes a direct measure of totally filled liquid volume \( V_x \) but also a direct or indirect measure liquid volume bonded to the goods \( \Delta V_L \) by capillarily and mechanically influence at prevailing design parameter values, i.e. R.P.M. chosen, sequence etc. due to the fact that the volume \( V_1 \) is known. In other words, \( N_x \) constitutes also a direct and indirect measure of the weight of the wash goods \( M_{LD} \) in dry condition,

\[ N_x = K_R \frac{M_{LD}}{3} F(M_{LD}) \left( 1 - \frac{f_0}{F(M_{LD})} \right) + V_1 K_R \]

The curve 95 in figure 12 shows this relationship for an assumed linear function of the moisture ratio \( f_c = F(M_{LD}) \) in accordance with figure 13. An empirically found relationship between \( M_{LD} \) and \( f_c \) - value can of course also be used for establishing of direct relationships between \( M_{LD} \) and \( \Delta V_L \). This means that the relation between \( N_x \) and \( M_{LD} \) can also be expressed
by means of a relationship depending on \( \frac{N_x}{K_R} - V_1 \), if so is suitable where the moisture ratio is not included in explicit form.

Generally viewed, the manufacturer of washing machines can now determine by tests for a particular type of machine and design and for each laundry washing programme, the optimum liquid volume for each operating cycles of the conventional washing process, which for each fixed value of \( V_L \) or \( M_{LD} \) gives the requested washing performance (\( AV_L \) and \( M_{LD} \) is in this context varied within the working range of the machine). Consequently, this concerns operating cycles of washing as well as operating cycles of rinsing and dosing. According to the invention the designer is completely free to choose desired values (volumes) at this optimization procedure and this by great filling accuracy and resolution, for example in steps of a few millimetres. This offers the designer completely new possibilities to choose the best temperature gradients and degree of mechanical affection of the wash load and specially different values for different textiles and degree of soiliness.

The problems and disadvantages associated with manual pre-selection of the wash goods parameters as wash load weight etc. in large steps via the front panel of the washing machine is avoided. The invention offers instead a measuring signal with high accuracy and resolution continuously varying with \( AV_L \) and \( M_{LD} \). In conventional washing machine designs there are only a few possibilities to change the filling volume. Usually there are only two liquid levels when the normal arrangement with liquid level sensitive pressure switches is used. In this comparison with conventional washing machine designs the invention theoretically corresponds, to thousands of pressure switches functions.

The relationships between \( N_x - V_1 K_R \) and \( M_{LD} \) are shown in figure 12 and also the volume of the additional filling 96 which is necessary at the conventional washing process to obtain optimum filling mentioned previously. The diagram figure 12 shows the working conditions at one operating cycle, the main wash. At other operating cycles, fillings necessary in these connections are carried out for optimizing the processing conditions.

In a corresponding manner the dosing of the washing detergent and detergent agent, (for pre-washing, main-washing, rinsing and rinse conditioning) is optimized in relation to \( AV_L \) or \( M_{LD} \) and to carry out additional fillings 96 and for other liquid volumes possibly participating in the washing and rinsing phase.

Thus, generally a curve can be established by tests describing the minimum of dosing of detergent/detergent agent necessary for requested washing
performance and consequently, optimum dosing can be carried through in combination with optimum water filling according to foregoing description.

Thus, by the invention the designer has access to an efficient procedure for careful adjustment of the dosing of the amount of detergent/detergent agent. The possibility to reduce the detergent/detergent agent use is very important today, both for the machine user and for the community, as great savings can be done in direct washing operation costs as well as in environmental protection investments.

If analysis of the wash goods composition according to the invention is carried out, fine-tuning of the optimizing procedure can be done. By information of the values $M_{L1}$, $M_{L2}$... and the textile structure i.e. inclusive type of fibers, the process can be adapted in such way that the concentration change of the washing/rinsing liquid products and other component transport mechanisms become optimum by choosing the shortest necessary processing time at prevailing wash goods composition for the type of fibers participating in the process but also in respect of other structure properties. (This implies that the optimum process time, for example of terry cloth can be changed from the order of 220 seconds to 150 seconds when the weight relation is changed from 4 kilograms to 2 kilograms). The rinsing operation cycles can also be optimized. The structure of the cloth or of the weave will influence the optimum rinsing cycle, for example, by the fact that particles from soil and detergent/detergent agents can be related to the filtering effect of the wash goods. For rinsing counter-efficient mechanical locking in the cloth or the weave can be avoided at the same time a minimum of rinsing volume is consumed.

Further on, the dosing of detergent/detergent agents can be adapted to actual water hardness and degree of contamination but also to the type of textile fiber of the wash goods. Hence additional dosing can for example be done considering the influence of the cotton fibers on the process.

Thus, the invention admits that considerable savings of consumptions of washing detergents, additive agents and water be attained and thereby also savings of electrical energy and cleaning operating time in comparison with conventional washing machines. By the method according to the invention a possibility is available to form the operation of the machine in such manner that nearly constant operating cost, calculated per kilograms dry wash goods, is obtained, independent of whether a small or large amount of wash goods is processed. This means that the operating
cost, apart from profits for the community, can be reduced by about 300% at small wash goods amounts compared to conventional washing machine designs.

Practical embodiments of the invention in agreement with previous description and figures 1 to 6 and figure 12 to 15, considering the application washing machines are shown in figure 7 to figure 11. Figure 7 shows schematically a conventionally designed washing machine operating with a rotatable laundry container 20 enclosed in a washing liquid container 21, which by way of example in the figure is provided with a recirculating circuit 22 for liquid.

The control apparatus fitted into the washing machine for control and optimizing of the washing process is in all respects in conformity with the apparatus shown in figure 1, meaning that the quantity metering means 23 and the valve means 24 are located in the inlet conduit 25, connected to the external water supply system.

The discharge conduit arrangement 26 of the laundry washing machine, consisting of pump, discharge flexible bellows and hoses, can also be provided with a mechanical valve of flap or ball type, known in the art, (not showed in the figure) at the connection 27 of the discharge flexible bellow to the washing liquid container. If from measuring technical standpoint important liquid accumulation, takes place during the analysis phases dependent on selected wetting technique and adopted analysis procedure the discharge conduit arrangement is provided with level sensing means of previous described type for measurement of collected liquid volume.

The sensor means 28 of the washing machine, operating according to the principle of direct moisture ratio measurement is located within the laundry container 20, implying that the sensor or sensors 28, in the corresponding way known from the tumbler dryer technique is sensing the moisture ratio of the wash goods. The wash goods is wetted by means of a central located nozzle or nozzles 29 or by the laundry container peripherally located nozzle or nozzles, e.g. as shown in figure 8 and possibly appearing excess liquid is recirculated to the conduits of the wetting system via circuit 22. The wash goods will during the wetting or desuturation phase according to foregoing description, touch the contact surfaces 30 of the sensor, dependent on the rotation of the laundry container which gives a signal co-varying with the moisture or moisture ratio. As has been explained earlier the sensor or sensors can be designed according to different operating principles, sensing liquid enclosed in
the space of voids of the wash goods. Preferably, resistive sensor technique is utilized implying that the resistance towards the passage of the electrical current of the network of liquid filled interconnected pores is registrated. The measuring signal 31 is transmitted to the control unit 32 for further processing and utilization for optimizing of the washing process in a way described previously. The afore-mentioned analysis phase can, for example, be carried out as one analysis step during wetting of the wash goods or as a series of analysis steps at intervals of different speed of rotation during increasing or decreasing R.P.M value i.e. during desaturation or saturation (wetting) with the external flow shut-off by valve device 24. The hydraulic system of the washing machine is in the latter cases provided with containers corresponding to liquid volumes appering.

With reference to previous descriptions direct moisture measurement can also be carried out by the sensor or sensors 33 located externally the laundry container in the annular space between laundry container and washing liquid container. Figure 9 shows schematically a position of a sensor in this design.

The other characteristics of the washing machine are in agreement with afore-mentioned features of embodiment according to figure 7. Direct moisture measurement in accordance with foregoing description in connection to embodiment, figure 7, offers as has been pointed out previously, advantages within the special market segment of the washing machine technique where the structure of a drum washing machine is combined with the structure of a tumbler dryer of drum type, by operating with a common drum, utilized both for the washing and the drying process. Then, the sensor means 28 according to figure 7 can be used for two purposes, firstly, moisture-measurement during the analysis phase and, secondly for moisture-measurement, i.e. control of residual moisture during the drying phase, implying within this market segment it is not necessary with additional washing machine components for introducing the new technique in accordance to the invention.

In figure 8 a third embodiment of a conventional washing machine provided with a control apparatus in agreement with the invention is shown. The machine is operating with a rotatable laundry container 35 enclosed in a washing liquid container 36 in a known way. By way of example the washing machine in figure 8 is shown, equipped with liquid recirculation system 37. The control apparatus fitted into the washing machine for control and optimizing of the conventional washing process coincides with the
apparatus according to figure 1, implying that the quantity metering means 38 and the valve means 39 are installed in the inlet conduit 40 which is connected to the external water mains. The discharge conduit arrangement 41, consists of discharge pump 42, collecting liquid volume 43, volumetrically determined by the sensors $S_3$, 44 and $S_2$, 45 flexible bellows and hoses and can be provided with a mechanical valve of flap or of ball type, known in the art (not shown in figure 9) at the connection 46 of the discharge flexible bellow to the washing liquid container 36. The collecting liquid volume $V_{1'}$, 43 determined by the sensors constitutes normally part of the conventional discharge conduit arrangement of the washing machine but can also be made up of a special volume or volumes, for example, containing a heating device for the laundry washing machine.

The volume and volumes can thereby be equipped with shut-off devices, regarding the conventional discharge conduit arrangement for reducing the liquid consumption during the conventional washing process if this volume or volumes only are utilized during the analysis phase. The collecting liquid volume can also be provided with special sensing zones at 47 and 48 with a small horizontal cross sectional area improving the sensing accuracy in the case level sensing sensors being utilized. The sensing zones can also communicate with particular sensor housings or sensor tubes which can be integrated with discharge conduit components of the washing machine or constitute separate components, in both cases defining the upper and lower level of the collecting liquid volume. The connection channels between the collecting liquid volume and the sensor housing or houses are thereby provided with suitable throttling units in order to damp i.e. smooth out the liquid movements at the rotation of the laundry container. The sensor housings can also be provided with devices for clearing by flushing and contineously flow through in order to protect the sensor housings against contamination and rests of washing detergent agent.

The collecting liquid volume, determined by the design of discharge arrangements chosen as small as possible with respect to the wetting procedure and desired washing performance data.

The analysis phase is started up by bringing liquid from the liquid supply source to the hydraulic system of the washing machine in such manner that the liquid level attains the sensor level $S_3$, 44 without wetting the wash goods. This can, for example, be carried out via the washing detergent container or by a separate conduit 49. When the liquid level is passing the sensor $S_3$ the sensor means is activated and a control signal 50 to
control unit 51 is obtained, implying that the liquid supply 52 to the wash goods starts via nozzle 53 during quantity measuring of supplied liquid by the quantity metering means 38. In connection hereto, at least periodically a rotation of the laundry container begins in order to obtain homogeneous wetting of the wash load according to the predetermined movement scheme of the analysis phase, implying that the analysis step is terminated with a predetermined constant value of number of revolutions per time unit. If necessary the wash goods can also be conditioned by rotation of a constant predetermined R.P.M. value before adjustment of the level of sensor S3. The indirect moisture ratio sensing during the analysis step is carried out in conformity with previous description and when the liquid level reaches S2, 45 the sensor means S2 is activated and gives off a control signal 54 to the control unit 51 which is emitting a pilot signal 55 for closing of the valve means 39, which means the analysis phase is terminated. Rechecking of the stability in S2-level is carried out and if so is necessary, after-filling is carried out directly into the V1-volume.

The sensors, of optional type, are installed in the most convenient manner at the most suitable points of the system, also including the recirculation system, in figure 9 marked with joint point 56.

In cases when a mechanically blocking valve exists, installed at the connection 46 and said valve reacting on the return flow to the collecting liquid volume, the sensor level S2 and if so is necessary the sensor level S3 can be located to the space of gap between the laundry container 35 and the washing liquid container 36. This sensor location is also utilized in the cases when internal recirculation of liquid to the wash goods occurs by means of per se known washing drum designs provided with shovel or chamber systems fetching liquid from the gap 57. The liquid caught and lifted in this manner by means of the shovel and chamber system (located in the drum or surrounding the drum), is at the internal recirculation spread over the wash goods in known way via draining holes after a certain turning angle of the drum and can, consequently, be utilized for the wetting procedure in accordance with the principles of the invention in these types of washing machine designs.

If a good repeatability exists in the draining procedure, implying that substantially the same liquid level arises in the hydraulic system after each discharge pumping operation the sensor S2, 44 can be eliminated. A suitable installation and ventilation of the discharge hose resulting in
controlled back flow after stop of the discharge pump is thereby improving the repeatability.

The analysis phase can also be modified in accordance with the foregoing description, the sensor operation then being adapted to that. In figure 10 a fourth embodiment is shown, forming a modification of the embodiment according to figure 8, adapted to determination of the composition and the textile structure of the wash goods during the analysis phase, foregoing the conventional washing process. The main components and the sensors of the laundry washing machine agree with the main components and the sensors in the embodiment according to figure 8. However, the recirculation system 85 with pump 60 has been completed with a multi-way valve 61 and with suitable number of conduits 62, 63 and 64 in respect to suitable flow through velocities, where said conduits are connected to the wetting system 65 and to the quantity metering means 66, which is provided with corresponding number of inlet conduits 67 and 68 and discharge conduits 69 and 70, the latter connected to the inlet 71 and 72 of the valve means 78.

The outlets 74 and 73 of the valve means are in turn connected, respectively, to the wetting system 65 and a detergent container 75, or another container communicating with the hydraulic circuit of the washing machine, such as washing liquid container 76 of the machine. The liquid contents of the container is regulated as requested by a valve means 77 by drainage.

The flow in the described conduits is controlled by corresponding valves, preferably of type solenoid valve located in the multi-way valve 61 and in the valve means 78. In this exemplifying case the wash goods analysis is carried out, as to the first analysis step, by the same method as has been described in connection with the embodiment according to figure 8. Accordingly, summarized this implies that the analysis phase is started up with regulation of the level of $S_3$, 79. At reaching of level $S_2$, 80 or by a predetermined time limitation the wetting procedure with increasing moisture ratio is interrupted. Dependent on if the time limitation or the $S_2$-sensor interrupts the wetting procedure different quantities of liquid is found in the volume $V_1$ which has been drained or is drained to level $S_3$ of the recirculation circuit, which in the case $S_2$-interruption is connected to the container 75 by the valve means 61 and 78. The container 75 is kept closed and the quantity measurement occurs by means of quantity metering means 66 whose informations is evaluated and is stored in the calculation unit of the control unit 81. When the $S_3$-signal 82 appears to
control unit 81 generated at the switching of the sensor $S_3$ to inactive mode, a pilot signal 83 is also generated to the driving motor of the laundry container whose speed of rotation is increased a R.P.M. value determined by the movement scheme of the analysis phase. Thereby, a liquid quantity $\delta_1$ 84 is removed from the previously homogeneously wetted wash goods by desaturation, said volume being collected in the $V_1$-volume and over the $S_3$-level, which said sensor thereby again has been activated. After suitable time interval the $V_1$-volume is drained to $S_3$-level again (the $S_3$ sensor inactive) by over pumping to container 75 during volume measurement of means 66. The $S_3$-sensor will again at switching (inactive) generate a pilot signal for increase the speed of rotation resulting in that the liquid volume $\delta_2$ is removed and collected in the $V_1$-volume and over the $S_3$-level, renewed draining to the $S_3$-level being carried out during volume measurement in accordance with the above description.

The analysis procedure is repeated a number of times, however, at least as many as the number of different textile fabrics or wares participating in the wash goods analysis, for which textiles known $f_C$-data have been pre-programmed in the calculation unit of the control unit. The liquid quantity which has been inter-stored in the container 75 is drained to the washing liquid container 76 of the washing machine to be utilized in an aforementioned manner at the washing process by opening the valve 77 before the start of the conventional washing process.

The calculating unit of the control unit 81 evaluates in previous described way by means of known $f_C$-data the dry wash goods weight $M_{L1}$, $M_{L2}$ ..., for the textile structures known by $f_C$-data in regard to which structures the wash goods analysis has been carried out. Further on, these analysis data are utilized in the calculating procedure for determining the optimum process parameter values in the conventional laundry washing process.

The analysis method can be modified in several ways par, for example, by utilization of the sensor $S_2$ instead of sensor $S_3$ or by introducing additional sensors for improvement of the measuring accuracy.

Furthermore, analysis can be effected after homogeneous wetting at high R.P.M. value by a centrally installed wetting nozzle head in the laundry container connected to the recirculation circuit in analogy with figure 7. After a preliminary wetting, also here time limited, the external liquid supply is interrupted and during lowering of the speed of rotation a well adapted, liquid spraying of the wash load ring in the laundry container is applied by the recirculation system draining the $V_1$-volume. Thereby the
wash goods will imbibe the wetting flow and increase the moisture ratio in accordance with $f_C$-data valid to this wetting case.

In an analogue way to what has been indicated for sensor $S_3$ according to figure 10, the $V_1$-volume drained during each analysis step is filled by external supplied and measured liquid directly supplied into the $V_1$-volume until liquid level $S_2$ is obtained. These partial volumes measured in this manner constitute necessary information for the calculating unit of the control unit for determination of $M_{L1}$, $M_{L2}$... and textile structure data by means of the known $f_C$-data, said values being utilized for optimizing of the following conventional washing process.

The described embodiments according to figure 7 to 10 schematically show laundry washing machine designs of drum type. The invention is in no way limited to this type of laundry washing machines but can advantageously be applied in all designs working with rotating laundry container or with fluid drivers of rotating or agitating type, such as pulsator- and agitator machines. Machines of agitator type of conventional design provided with spray system for the conventional washing process is specially suited here, by the fact, that double functions can be given existing washing machines components. The spray systems utilized for e.g. rinsing operating cycles can also be utilized for wetting during the analysis phase. The basic operations included in the control apparatus according to figure 1 are operating in previous described manner but are installed with respect to a standing laundry container 88 and washing liquid container 89 belonging to an agitator machine, according to the schematical figure 11, where the valve and quantity metering means 91 and 90 are located in the inlet conduit while the wetting nozzle 92 coincides with existing spray arrangement. The volume of appearing collecting liquid can be established by level sensing sensors of previous described types 93 and 94, respectively.

In a way corresponding to that just described for laundry washing machines, control apparatus implying load adaption can be worked out for a dishwasher by introducing an analysis phase. Preferably, the collecting liquid volume $V_1$ is located according to figure 16 or 21. The excess liquid, which is not adhered to the walls, in the free air space, or adhered to the dish load i.e. washing-up goods or food ware of the wash chamber under influence of the liquid flow 127 poured over the food ware by the spraying arms 100 and 101 or the nozzles 125, according to figure 16 and 21, will in corresponding way as in the laundry washing machine case, be collected in a collecting liquid volume $V_1$, the liquid filling
then being interrupted when stationary wetting and adherence or binding conditions have set in, implying that the liquid level finally reaches the sensor level $S_2$, 102, which has been elaborated with a sensing zone with a contraction 103. Also here, if so is required rechecking of filling levels and conditioning of the surfaces of the food ware before the analysis phase are effected if it is necessary in respect of stability and quality of the food ware.

Thus, when the balance prevails between the liquid supplied to the volume $V_j$, 104 and liquid drained off from volume $V_j$, a certain liquid volume $\Delta V_C$, 105 bonded to the food ware exists in the wash chamber, constituting a part of the liquid volume $V_X$ supplied during analysis phase. The number of standardized place settings or corresponding exposed surface of food ware will by that be determining for the absolute value of $\Delta V_C$ as to some extent the degree of soiling of the surfaces of the food ware. As $\Delta V_C$ is determined during the analysis phase of the dishwasher programme at stationary flow conditions also a liquid volume $\Delta V_{DFP}$ has been established corresponding to an accumulation of liquid because of formation of liquid films and of adhesion forces acting along the wetted surfaces of the machine as well as of a liquid volume $\Delta V_{DRP}$ because of accumulation air born liquid in the wash chamber of the dishwasher. Thus, the relationship between the number of pulses of the volume measuring component, $N_X$ and $\Delta V_C$ will be

$$\Delta V_C = \frac{N_X}{K_R} - V_j - \Delta V_{DFP} - \Delta V_{DRP}$$

If the analysis starts from a drained off dishwasher hydraulic circuit the volumes corresponding to conduits and spraying arms are to be included in the term $\Delta V_{DFP}$.

Analogously, to relationships discussed earlier between $M_{LD}$ and $\Delta V_L$, a relationship according to figure 20 between the dish load degree $E$ (numbers of standardized place settings or totally exposed surface of corresponding number of place settings) and $\Delta V_C$ can be established by tests for existing dishwasher programmes and usually operating conditions i.e. a function $H(\ )$ can be established.

Summing up, a relationship is obtained, consequently, obtained between dish load degree $E$ and $N_X$ analogical to previously described relationship for $M_{LD}$ and $N_X$ i.e.
\[
B = H \left( \frac{N_x}{K_R} - C; SM \right)
\]

where

\[C = V_1 + \Delta V_{DMF} + \Delta V_{DRF}\]

constitutes a dishwasher design factor determined by the dishwasher concerned and SM a parameter value considering the surface conditions of the food ware, in first hand the degree of soiling of the food ware. In particular, in case when the liquid pouring of the food ware is carried out by means of the primary spraying system of the ordinary hydraulic system during the analysis phase, it will be created, by reason of the design and the position of the jet nozzles, a flow field and a liquid distribution in the wash chamber of the machine, which are dependent on the dish load degree of the dishwasher. This implies the value of the liquid volumes $\Delta V_{DMF}$ and $\Delta V_{DRF}$ are influenced by the change in the shadow effect, counted from the openings of the jet nozzles to the interior walls and the free air space of the wash chamber, which is arising at the occurrence of larger or smaller amount of dish loads. Consequently, this is causing the dishwasher design factor $C$ according to above to be partly depending on the amount of food ware i.e. on $\Delta V_C$, why this dependence can be introduced into the mathematical relationship for $\Delta V_C$ according to above. Accordingly, $\Delta V_C$ may be determined by utilization of an iterative process (trial and error calculation) and by help of, for example, experimental data concerning the design factor. This procedure of calculation can easily be done by microcomputer technique.

The collecting liquid volume according to figure 17 is constituted of a separate chamber or is integral with the dishwasher bottom component. The collecting liquid volume, preferably geometrically displaced in relation to centre of the dishwasher, coincides with the cleansing liquid sump (water sump) and is provided with a main strainer 110, fine-mesh strainer 111, inlet to the drain recirculation pump of the primary spraying system 112, inlet channel to drain pump 125, inlet conduit for external, measured liquid flow 113 and the sensor housings in form of tubes 114 and 115, where 114 and 115 show two alternative positions of sensor housings allowing different sensor operations. Furthermore, on the collecting liquid volume is provided with an upper sensing zone 116 and a lower sensing zone 117, designed in a manner which has been described in connection with the sensing zones of the washing machines according to
figure 8. By the contraction of the sensing zone and by suitably chosen sensor operations a minimum of measuring errors is obtained in value of the volume $V_1$ at the activation of the sensors. Figure 18 schematically illustrates the sensor function $S_2$ in a radial cross-section through the upper sensing zone 116 at optically operating sensors. The light guide 118 is connected to the sensor at 119 where the switching operation can be be effected, for example, by blocked or changed light transmission. The main and fine mesh strainer of the collecting liquid volume is in known manner assembled in said volume for collecting rests of food and other contaminations. It is essential here that the fine mesh strainer always permits the return flow from the wash chamber to reach directly the collecting liquid volume without flow restrictions and at a minimum of recirculation of soil to the cleansing liquid. In order to facilitate and improve this flow process the upper border surface 120 of the collecting liquid volume can be provided with channels and nozzles 121 for cleaning the fine-mesh strainer by backflushing i.e. from its underside, the flow process being schematically illustrated in figure 19. In this way the fine-mesh strainer, can for example, be effectively cleaned during the outset of the analysis phase when the risk for accumulation of food rests is greatest, at the same time as the strainer cleansing liquid utilized always is brought back to the collecting liquid volume and participates in the volume measuring procedure. Further on, the collecting liquid volume can alternatively according to above be provided with a tubular formed sensor housing 115, i.e. a sensor tube of an type previous described in connection with the washing machine embodiment of figure 8. The alternative position of the sensor tube in accordance with 122, figure 17 (dotted line contour replacing alternative I) shows a possible position of a sensor tube which admits a switching operation free of liquid of sensor $S_2$ 123 and $S_3$ 124 by location of optical switching operations above the maximum liquid level 109. In order to improve the liquid flow within the wash chamber from measuring aspect during the analysis phase, the dishwasher can according to a second practical embodiment according to the invention be provided with a separate liquid distribution system 125 for liquid pouring or sprinkling 127 of the food ware according to figures 21 and 22. The distribution system 125 fixedly mounted or connected to the racks for the supporting food ware, preferably consists of an series of pouring openings or nozzles, the latter in a technically known manner, admitting an even and well-distributed liquid supply of fine droplets. Consequently, the distribution system spreads the supplied, volumetrically
known, liquid volume 125 homogeneously over the horizontal plane of the wash chamber and directs the flow 127 vertically during adapted liquid velocity. The food ware will in that way be poured or sprinkled by a homogeneous liquid flow without strong jet forming, causing formation of a liquid film on the exposed surface of the food ware, whose film thickness t 128 is known of fluid mechanical reasons and whose t-value is only weakly influenced by variations in the flow rate of the distribution system and by variation in the tilting of the liquid swept surface of the food ware. At strong variations in the flow of the distribution system a correction can be done if so is necessary, because the dependence of the liquid film flow is known as well as the magnitude of the flow by means of the quantity measuring technique. Consequently, the relationship for the liquid amount $\Delta V_C$ bonded to the food ware can be expressed during stationary conditions by the formula

$$\Delta V_C = \sum \frac{n}{t} \cdot \bar{t}_i \cdot B_i \cdot \bar{t} \cdot B$$

where $\bar{t}_i$ : designates the average thickness of the liquid film for the food ware component $i$

$\bar{t}$ : designates the average thickness of the liquid film for all food ware components

$B_i$ : exposed food ware surface - component $i$

$E$ : exposed food ware surface of all food ware components, i.e. the dish load of the of the dishwasher

$n$ : the total number of components constituting the dish load during the dishwashing process

Because the distribution system spreads the flow, substantially vertically during well-adapted velocity, the liquid quantity, $\Delta V_{DME}$ and $\Delta V_{DFP}$ accumulated in the interior of the dishwasher are reduced distinguishing this system from liquid pouring by the conventional spraying arms of the dishwasher according to figure 16. Supplied flow 127, according to figure 21, which can be constituted of only volume flow drained off from the supply water mains or a mixture of this flow with a flow from the recirculation pump of the primary spraying system, will in this way be concentrated only to the surfaces of the food ware at which the accuracy in the determination of dish load degree is increased. By utilization of the component according to the third aspect of the
invention, which permits a resolution of about 3000 pulses per litre liquid or higher, a measuring accuracy of the dish load degree is possible, which discloses a change of the amount of food ware with one or a few pieces.

For reducing the manufacturing cost the fixed distribution system of liquid according to figure 21 and figure 22 can be replaced by a movable system applied to the conventional spraying arms, shown in the figures 24 and 23. The centre 132 of the spraying arms is provided with a separate channel 133 fed by pipe 134 whose channel distributes the supplied flow to the nozzles 135 placed along the spraying arms which by rotation distribute the supplied flow 126 uniformly over the food ware in accordance with previous description.

An alternative to this form of movable distribution system is to utilize the conventional spraying arms without nozzles 135, according to figure 16, but in that case with lower supply pressure caused by flow throttling in the conduits of the primary spraying system or by lowering of the speed of rotation of the recirculation pump.

By the invention the advantage is attained of automatic adjustment to the dish load degree B and information about this value. According to the same procedure which has been described for washing machines (compare figure 12) the dishwasher designer can adapt supplied liquid volume and dishwasher detergents and agents in each operating cycle of the dishwasher programme so that optimum cleansing result is obtained (highest cleanliness of the food ware to the lowest cost). However, here the limitations prevail, associated with the operation of the hydraulic circuit of dishwasher of conventional design, namely the fact that the liquid volume adapted to the dish load according to this invention will be distributed within the whole interior volume of the wash chamber by the rotating spraying arms. In this way a larger liquid volume, time and energy consumption will occur than motivated by the amount of food ware at hand when the dishwasher is only partly loaded. By introducing a stationary valve arrangement in the centre of the spraying arms according to figure 26 and figure 27, the flow and thereby the liquid supply pressure to the spraying arms can be limited by the valve device to predetermined sectors i.e. to partial areas of the actual dishwasher rack. By placing the food ware by the user of the dishwashers within a sector or sectors of the rack of the dishwasher corresponding to the pre-setting of the axially displaceable slide valves 141-143 and 160-161 according to figures 26 and 27 or alternatively by rotatable valve setting in circumference, the
disadvantages of the operation costs associated to conventional dishwashers operating with partial dish load are eliminated. Consequently, the invention admits a minimum of liquid, time and energy consumption, firstly, by adjustment of the liquid volume determined by the dishwashing programme according to real food ware surfaces or quantity i.e. to the dish load degree, secondly, by focusing of the adjusted liquid volume to the partial sector of the dishwasher rack where the food ware is placed.

In figure 25 the radial distribution of the jet pressure is shown as an example corresponding to a valve arrangement in accordance with figure 26 and figure 27 with valve segments of the size 120° and 60°. By pressing down also the valve segment 143 and 142 the area in the dishwasher rack with the jet pressure is increased from "solid line" pressure distribution (120°) 144 to "dashed line" pressure distribution (120° + 60° + 60°) 145. The valve arrangement with the flow through area to the spraying arm determined by the turning angle (rotation) of the spraying arm also gives the advantage that, it within the sprayed area of dishwasher rack, will arise two zones 146 and 147 with lower jet pressure than the maximum 144 suitably for fragile food ware as glasses and cups. This is realized by the fact, that the central fixed nozzle 148 is receiving liquid flow from the dishwasher primary spraying system through opening 149 and the liquid pouring supplied flow through the conduit 150 via the segmental valve slides 141 to 161, are connected with the channels 151 and 152 of the rotating spraying arm. Consequently, during each revolution the channels 151 and 152, respectively, of the spraying arm will by rotation in the circumferential direction successively open up the passage (increase the area of the flow) from the fixed nozzle 153 to the channels of the spraying arms when said passage is not blocked of any of the valve slides.

Figure 26 shows, firstly, an open valve slide 154 and, secondly, closed valve slides 155, 156 and 158 resulting in that jet pressure only exists in the front part of the dishwasher rack (180°).

The filling technique described for the cases of application dishwasher and washing machines according to previous description can also be used within other engineering areas, for example, heating and sanitary technique. Valve- and quantity metering components, preferably brought together can also here carry out optimizing of the filling phase.
Thus, the methods and the means according to the invention can be utilized at filling of process goods container containing process goods having non-absorbing properties i.e. with reference to figure 3, an analysis phase where the parameter value describing the liquid bonded to the goods remains unchanged during an analysis phase extended between two analysis conditions (states). A simple application example is here optimum filling of the bath tube utilized by persons of different size.

Thus this application is specially suited for hotel establishments for energy saving (hot water).

By the fact that the parameter describing the liquid bonded to the goods is not changed, and by locating sensor level $S_2$ on a suitable level (height) in the bath tub for obtaining a representative measure (value) on the displacement volume of the bathing person (normally lying in the bath tube) the possibility is obtained to make a second filling for complete bath comfort in suitable relationship to the displacement volume of the person. In this way there is obtained automatic adaption of the hot water volume (consumption) to the size of the bathing person at complete comfort without intervention of the bathing person. The sensor level $S_2$, according to earlier description is given by the closed outlet of the drained bath tub.

The invention can also be utilized for control of nutritional supply and/or watering purpose where the parameter value is referred to the moisture of the soil, PH-value etc., whose values are sensed by sensors of known design. Here the process goods amount is constant and the value of the collecting liquid volume zero why the technique is utilized for optimum controlling of the process for obtaining, for example, optimal nutritional supply, water supply etc. which is detected by the sensor or sensors, which in accordance with earlier description when an optimum value is obtained also interrupt the nutritional or water supply.

A control system of this kind will be utilized as well in larger green houses as in green houses adapted to homes. In the latter case several different plants, vegetables, and mushrooms are cultivated within the same storage compartments in different boxes, for which reason a valve component provided with 6 to 8 outlets is specially suitable.

The method and apparatus for carrying into effect are not limited to the embodiments shown but can be further modified within the scope of the basic inventive idea according to the first aspect of the invention.
A second aspect of present invention concerns a method and a device according to the preamble of claims 48 and 36, respectively.

Control and monitoring systems are known which are used as programmers in household machines, said systems operating electronically and/or electromechanically, or applying different forms of hybrid solutions. Components connected to the programmer, such as pumps, motors and valves and controlling and monitoring sensors, are designed, with few exceptions, as electromechanical devices, which means that the component has a mechanical functioning built in, which is controlled and/or monitored by electrical signals of low or high voltage character, each component thus requiring a pair of electrical wires having corresponding terminals for connection of the necessary cable. In this way it is necessary to provide bundles of discrete wires or ribbon cables within the casing of the household machine, where each wire, specially those on low voltage level for signal transmission, run the risk of being exposed to electromagnetic interferences, which will result in malfunctions if not expensive interference protection units are installed.

These conventionally used sensors are, due to their electromechanical design, costly to manufacture and have a limited service length by wear, unresistance to humidity, contact stickling, progressive ageing and pure manufacturing defects, all associated with the existence of a plurality of movable parts. An example of such sensors is the pressure switch (pressostat) conventionally used in household machines wherein normally two or three are used for controlling (operative pressure switches), for example, the washing or dishwashing process and usually one being used for supervision (monitoring pressure switch). Pressure switches in use include a pressure affected chamber provided with a rubber membrane which releases under influence of pressure a spring loaded contact mechanism (relay) for breaking or closing the current circuit. The reading accuracy or error of the pressure switches will thus be effected by hysteresis in the switching sequence as well as by deviations in the mechanical basic setting at manufacturing, as said setting is performed mechanically by a spring loaded set screw.

The pressure switch operations utilized in traditional household machines are also dependent on the fact that the household machines are provided with a pressure dome and a connecting hose between the pressure dome and the housing of the pressure switch, as the pressure transmitting fluid affecting the pressure chamber of the switch is air. If the pressure switches are used for protection against leakage or over-filling, the
necessary hose and connection point constitute a risk factor in that the monitoring functioning can fail to appear after a certain operating time as a result of deposit of soil and detergent rests in the hose or in the connection point thereof.

If the pressure switch is utilized instead for control purpose, the switch will be affected, in the case of a laundry washing machine, by the relative movement between the laundry container, i.e. the tube, and the pressure switch housing, by the amount of water absorbed by the wash goods and by the movement of the wash goods in the container.

For supervision also other technical solutions are applied, uncomplicated as well as complicated systems. Known simple solutions utilize a liquid absorbing sponge fixed between two walls. At swelling upon liquid absorption the contact mechanism is affected. Other known solutions use a float mechanism mechanically acting upon the inlet water valve or an additional inlet valve operated by an electrical signal. Finally, there are also known advanced monitoring systems operating with multi-wall hosing, or twin hoses, for supervision of the hose connection between the water mains and the household machine.

According to the second aspect of the present invention it has for its project to provide a simple, coordinated control and monitoring system operating without conventional sensors, e.g. electromechanical pressure switches.

A further second object is to provide a system free, from electromagnetic interferences, by utilizing optical means for generating and transmitting signals, such as light guides operating with one or several signal channels which also means that extremely simple sensors can be used which operate without switching forces and mechanically complicated parts.

Instead the sensors used preferably operate by changing the light intensity in the light guide at signal transmission. In the simplest case this can mean blocking and deblocking the optical path by displacement of a sensor means element corresponding to light guide diameter. An extremely simple sensor operation without movable parts is obtained by making use of the changing reflection or refraction of light in the presence or absence of a liquid in a sensor housing.

A further third object is to provide a control and monitoring system which is co-ordinated optically by a light guide, responsible for the signal transmission operations of one or several transducers, preferably for quantity measurement, as well as the sensor function of said optical sensors. The combined optical signal obtained thereby from the
series-connected sensors and transducers can be analysed, in doing which certain signals can be distinguished from others by separating signal characteristic resulting in the feature that certain sensors can be assigned to the function of a monitoring sensor in relation to operative or control sensors. These simple monitoring sensors take care of alarm functions or other suitable measures when unnormal operating conditions appear in a process or other fluid procedure.

Finally, it is an object to provide a system with a plurality of series-connected functions where the same light emitting means and possibly light receiving means can be used for several optical links or channels in the same light guide and to produce such sensor designs that simple optoelectronic components, co-operating with low cost fibres such as plastic fibres can be used, in all resulting in very low manufacturing costs for each function of the system.

The objects of the invention are attained and the above-mentioned disadvantages related to electromechanical pressure switches are eliminated by the inventive features defined in claims 48 and 36.

Figure 28 shows a system or a component 190 operating with a fluid running through and/or with fluid accumulation. A flow 191 is supplied to the system or the component at connection point 192 and is accumulated and/or discharged at connection point 193. The system or component is controlled by an operative sensor means S_{21} 195 and supervised by a monitoring sensor means S_{11} 194. The sensor means S_{21} and S_{11} can be composed of one or several optical sensor functions optionally positioned within the system or the component. The sensor means detects physical states as pressure, temperature, moisture, level, fluid flows (volume flow) essential for control and/or monitoring of fluid system or fluid component. The flow 191 or totally supplied amount of fluid (volume, mass) can be determined by quantity metering means 205 and be controlled by flow regulating means 196, preferable valve means for regulation or opening and closing. If only monitoring takes place by sensor means S_{11} with, for example, the protective technical measure "alarm", the quantity and/or flow regulating means may be left out.

The sensor means S_{11} and S_{21} are series-connected by a common light guide 197 being part of an optical link 199 in which also the quantity measuring means with its optical recording transducer 205, designated S_0 is connected in series. The sensor signals are transmitted to the control and/or monitoring unit 198 by the common optical link 199. The signal 200 is made up of an optical combined signal with a resulting signal characteristic,
which is dependent on the individual signal characteristic of the optical sensors and transducers. With signal characteristic is intended the physical features of the light signal, such as light intensity (amplitude-optical power), light wavelength, light phase, frequency or polarization. These signal features are determined by a precise parameter value or several precise parameter values defining the signal characteristic.

The combined signal 200 is detected by detecting the means 201 of the control and/or monitoring unit 198, where a predetermined signal parameter value or values giving rise to the generation of a control or monitoring signal, as pilot signal 202, to the valve means, if applicable, or an other signal 203 to the fluid system or the fluid component. The light guide consists preferably of a fiber optic cable composed of one or several fibers in the latter case suitably arranged, for example, in a given pattern adapted to sensors inserted in the circuit and to desired signals. The light circuit is operating with light emitting means 204, preferably, common for several circuits, emitting light of an optional light wavelength adjusted to the sensor functioning such as IR-light, UV-light etc.. The optical detecting means 201, selected with regard to best signal conditions for the light circuit, can comprise one or more optoelectronic/electronic units. In the simplest case the detecting means consists of an optical signal and the emitting means of a bulb.

The method according to the second aspect of the invention will now be described with reference to the principle figure 29, representing an simplification of figure 28. At point 210 light emitting means is shown and at 211 light detecting means is shown. In the optical link formed by the emitting and detecting means 210 and 211 and the light guide 212 there has been inserted in series an operative sensor means 213 comprising one or more optical sensors and/or transducers $S_{21}$ and $S_{0}$, respectively, and monitoring sensor means $S_{11}$, 214 also comprising one or more optical sensors.

A light signal of constant or periodical character is emitted by the emitting means 210. The operative sensor means 213, sensing a physical state essential for control of the fluid system or the fluid component is modulating the light emitted (signal) from the emitting means in covariation with the change of the physical state, which can be a state defined by pressure, temperature, volume flow, level etc. in relation to the fluid process or the fluid component. An example hereof is an optically recording transducer for fluid flows, where the sensing element (e.g. a ball or a rotary member) modulates the light from the light emitting
means by affecting the same at each passage of the element by changing the light intensity. In the extreme case modulation takes place by total transmission of the light (through the transducer) in a first position of the sensing element, i.e. free or deblocked light passage occurs, while the light dies out in a second position of the sensing element, i.e. light passage is total blocked (zero light intensity). In conventional transducer design this means that a approximately pulse shaped signal modulation is carried out by the transducer of the operative sensor means.

The described signal sequence is showed in figure 30. The light emitting means 210 is assumed, in this simplified example with straight forward intensity-modulated sensors, to emit light with constant intensity represented by line 215 in figure 30a. The optical sensor, i.e. in the example the transducer for fluid flows, modulates the light and gives cause to the signal 216. The modulated signal is detected by the detecting means 211 in doing which the signal 217, co-varying with signal 216, is generated. This is true under the presumption that the signal between the operative sensor means 213 and the detecting means 211 is not affected by external factors. If now monitoring sensor means is introduced in the optical means according to the dashed contour 214 in figure 29 having the signal characteristic according to figure 30c, i.e. a device operating with discrete signal levels marked with level "active", i.e. free or deblocked light passage, and level "inactive", i.e. totally blocked light passage, the signal between the emitting means 210 and detecting means 211 can be affected. In the optical link between the monitoring sensor means 214 and the detecting means 211 an optically combined signal appears whose signal characteristic in the general case is determined by sensor means 213 and 214 at given a signal from the light emitting means. In this simplified case it means that when the monitoring sensors means 214 is changed from an active level as a result of an abnormal external event related to the fluid process or the fluid component, the combined signal 218 will also change its signal characteristic 219, defined by the signal parameter value or values i.e. in this case by the light intensity amplitude falling from the value marked by 220 to zero level, which is illustrated in figure 30d for the combined signal. In the the general case with another signal characteristic of the monitoring sensor means 214 than that shown in figure 30c, the combined signal will change in correspondence to this characteristic, which change, instead of an altered light intensity amplitude according to the example, can be an altered signal parameter.
value caused by a change in light wave length or light phase, frequency or polarisation.

This changed signal characteristic of the combined signal as a result of an external, unnormal event detected by means 214 can thus be discovered, i.e. detected, by the detecting means 211 by means of a signal processing unit and/or computing unit (not shown in the figure), connected to said detecting means. The characteristics of the light emitting sensor means and of the operative means 213, defined by one or several signal parameter value or values, are known and the detecting means can immediately detect the parameter value or values of the combined signal 218, which have been changed by influence from the monitoring means since also the characteristic of the monitoring sensor means is known. In the simplified example in figure 30d this means that the light intensity amplitude of the combined signal falls to zero level at activation of the monitoring sensor means 214, and this happens independent of the signal generated by the operative sensor means 213 i.e. the transducer for the fluid flow. This is explained by the fact that the signal characteristic of the monitoring sensor means (see figure 30c) has been chosen in such manner that it optically dominates or is overruling the signal characteristic of the operative sensor means 213 (see figure 30a), which in the simplified example of activating means 214 implies blocking of the light passage in the light guide, transmitting the combined signal 218. Consequently, the changed signal parameter value or values detected by detecting means 211 ensure that the unnormal event is known and that suitable alarm or monitoring signals can be generated.

If instead the signal characteristic of the monitoring sensor means 214 is changed in such a way that it at inactive sensor status does not totally block the light passage but gives rise instead to a reduced light intensity amplitude compared with the foregoing case, for example, by only partially blocking the light guide by the probing body of the monitoring sensor means, it is realized that the characteristic of the combined signal is altered corresponding to an intensity level 221 in figure 32, having a parameter value greater than the zero level, i.e. an intensity amplitude greater than zero according to figure 32. In other words, a signal with reduced optical power is transmitted in the light guide. Consequently, the change of the parameter value at the external, unnormal event detected by the detecting means gives rise to a changed amplitude in figure 32. Thus, in this case, by lower degree of of optical dominance, the signal modulated by the operative means 213 is available, said signal
carrying information by the number of appearing pulses, as illustrated by the case of a digitally operating transducer for fluid flows. Each optical pulse generated by modulation gives information on the amount passed through the transducer by means of the transducer calibration constant indicating passed volume per pulse (i.e. a characteristic or parameter value for this type of transducer). This constant will of course not be affected by any change of pulse shape occurring later in the light guide, caused by the monitoring sensor means. This signifies according to the idea of the invention that the information carried by the signal modulated by the operative sensor means 213 is maintained at the same time as the characteristic of the modulated signal (the parameter value or values) is changed by the monitoring sensor means. In the simplified example this means that the parameter value of the signal modulated by the transducer is known and allowed to vary within a predetermined interval. If the pulse width is chosen as parameter value of the modulated signal (after pulse shaping) the pulse width will vary from \( \Delta t_{p,\text{min}} \) to \( \Delta t_{p,\text{max}} \) depending on the working range of the transducer. See figure 31. As soon as the detecting means detects a pulse width which violates these limit values (the parameter values) an alarm- or monitoring signal is generated. This can be done in the latter example according to figure 32 without loosing information about the quantity passed through the transducer.

In an analogous way other signal parameters can be used. If the monitoring sensor means instead of exerting intensity modulation, is operating in accordance with the principles of wavelength modulation the monitoring sensor means can change the wavelength of the combined signal, which in an analogous manner is detected by the detecting means, for example, by utilizing of the changed characteristic of the photodetector for different light wavelengths. In this fashion, the idea of the invention can be varied in a plurality of ways with utilization of the known characteristics which will be the result of modulation in different manners and by influence from the monitoring sensor means, i.e. by changed light intensity, phase, frequency, polarization or wavelength. Consequently, the monitoring signal is allowed to alter the signal modulated by the operative sensor means, in a way according to the foregoing description, the monitoring signal is operating optically dominating the modulated signal a signal condition which is reflected by and utilized in the combined signal.

The method according to the invention also comprises the technical measuring possibility to combine several series-connected sensor
functions, where at least one sensor means operates with a continuously varying output signal as a function of the physical state followed. This implies that the operative sensor means 213 in this case is made up of a transducer or a sensor where the absolute value of the modulated signal, instead of the pulse number of the digital signal, is a carrier of information. This can be illustrated by the example of a soil transducer which is passed by a contaminated liquid, the transmitted light of the optical link being allowed to pass through or be reflected by the contaminated liquid when passing a suitable shaped light gap. Here the light gap consists of two parallel surfaces of which the light emitting, sensor surface distributes substantially evenly the light of the optical link across the surface, for example, by a suitable distribution of the fibres across the sensor surface. The optical sensing surface will collect evenly light passing through the light gap when this is passed by a clean fluid, said light being propagated through the light guide with its signal characteristic unchanged, which light guide is connected to the sensing surface (here the light attenuation by the clean fluid in the light gap is neglected for the sake of simplicity. If instead the fluid passing the light gap is carrying contaminations whose numerosness and particle size is defined in known manner by numbers and an mean radius, the light absorbed by the soil particles can be determined by the ratio between the intensity of incidencing light striking the sensing surface in absence of particles and that in the presence of particles. If it is assumed that the plane-parallel surfaces have an area of length a and width b and that the contamination volume in the light gap is V (where V is calculated from the numbers of soil particles with the mean radius \( r_m \)) the contamination volume V can be determined accordingly:

\[
V = \text{const} \cdot r_m \cdot u
\]

where \( u \) denotes the relative light intensity absorption in percentage terms of incidencing light striking the sensing surface in the presence of the contamination volume V in the light gap with the soil particles having mean radius \( r_m \) (by knowing the light gap dimensions and the flowing through velocity the constant is also known theoretically, however, in practice the constant is determined by tests).

If a sensor means of this kind is utilized for the operative sensor means \( S_{21} \), connected in series with a sensor means operating with discrete signal levels according to the foregoing description, the information of
the optical signal, in the form of an analogue absolute value, can always be maintained without affecting or preventing the sensor functioning of the discrete operating means. Because the switching level, considered as an amplitude value of the light intensity, always is lower than the lowest amplitude value of the continuously operating sensor means within its whole working range, the analogue device operates independent of the discrete device until the latter intervenes and reduces or blocks the signal to the detecting means. Thus, also in this case the discrete operating means will work with optical domination in relation to the continuously operating means.

The light intensity amplitude of the combined signal as a function of the degree of contamination is schematically illustrated in figure 33. At the soil degree $X_1$ the light intensity assumes value $Y_1$. The lowest light transmission at the highest soil degree corresponds to the value $Y_2$ at the same time as the switching level of the discrete sensor means 222 is lower than $Y_2$ and corresponds to value zero at blocked position. This means that the discretely operating devices when applied as described as well as when applied as previously described, will have overruling function compared to the operative sensor means and, consequently, can always intervene and change the sequence in progress related to the fluid process or component. Practical applications are e.g. filling and draining processes which can be monitored by the discrete sensor means and controlled by the operative means.

If leakage has been detected by the monitoring sensor means, the filling or draining sequence is immediately stopped, without any larger volumes of fluid flowing out into to wrong locations in the system or the component. In order to optimize the operating mode of the sensors, the light wavelength is chosen in a way which best matches the intended functions. Hence, the IR-light is chosen when sensors non-sensitive to soil are specified whereas UV-light can be used for soil detecting means described in preceding text. Practically this is realized by two optical links included in the device in parallel with separate emitting and detecting means. Due to the fact that only very small displacements with negligible switching forces are necessary or by the fact that sensors without mechanical displacement can be produced, using the refraction and transmission features of light in different materials and fluids, reliable sensors, manufactured at low cost are obtained.

Sensors belonging to a the first group are produced by the light guide, preferably a fibre optic cable consisting of one or more fibres of glass
or plastics, being divided and connected to a sensor housing adapted for installation in the system or component. In the sensor housing the light transmission in the light guide is affected by the sensor blocking or deblocking the light transmission of the light guide or the fibre link totally or partially by mutual lateral displacement of the end surfaces (assuming a centered position at maximal light transmission) formed by division (of the fibre or fibres substantially perpendicular to the fibre axis) or by lateral displacement of a member, wholly or partially blocking or filtering the light transmission, said member being moveable in the gap of the divided light guide. The divided light guide or said member is joined with a probing body located in the sensor housing and at least partly made of materials or combinations of materials, as bimetal, memory metal, moisture sensitive, dimension-changing substances etc. or the body is formed as a float or pressure sensitive membrane, sensing external physical states as temperature, pressure, moisture, liquid level etc.

A second group of sensors can be produced where the sensor functioning is obtained by, the feature that the sensor blocks or deblocks the light transmission of the light guide or fibre link totally or partially by the direction of the light path being changed or by attenuation of light intensity in the light transmission through or reflection against one or more, in the light path of the sensor inserted, curved or plane boundary surfaces between the solid material of the sensor housing and the fluid enclosed in the sensor housing, and detected by the sensor. The sensor housing material and said fluid have different refractive index, causing a changed sensor signal when exchanging the enclosed, sensed fluid for instance from gas to liquid or from liquid to gas.

A third group of sensors can be manufactured where the sensor function is obtained by the feature that the sensor changes or deblocks the light transmission of the light guide or the fiber link, partially by introducing in the light path a fixed or movable optical filter or reflecting surface sensitive to pressure, temperature or moisture to alter the light transmission or reflection conditions in co-variation with the pressure, temperature and moisture of the sensed fluid, the light wavelength or light intensity changed by the sensor being detected by the light detecting means.

Finally, a fourth group of sensors can be produced where the sensor operation is obtained by the sensor being made up of an undivided fibre or fibres changing the light transmission of the fibre link in co-variation.
with the working temperature, working pressure and bending radius of the fiber, or the ambient moisture. Practical embodiments of the invention according to the second aspect there of will now be described by way of example with reference to figures 34 to 42.

Thus, figure 34 illustrates schematically a device 230 according to the invention delivering control and monitoring signals to an electronic and/or electromechanical control unit or programmer 231 which controls the fluid process of a household machine, such as a laundry washing machine or a dishwasher. The process goods container 232 of the household machine, i.e. the liquid container or tube and the processing or wash chamber for the food ware, respectively, enclose the process goods 233, i.e. the laundry goods and food ware, respectively. Liquid for the laundry or cleansing process is supplied by a liquid flow 234, flow regulated by valve means 235, i.e. normally by the water inlet valve of the household machine. The liquid flow 234 can be determined by means of quantity metering means 236 in the case the household machine is provided with such a component. The conventional discharge arrangement 237 of the machine is provided with operative sensor means $S_{21'}$ 238 for controlling of the laundry and cleansing, process respectively by regulating the amount of supplied liquid in various phases of the laundry and cleansing process, or for determination of the load conditions in an initial analysing phase.

The operative sensor means 238 is component of a first light circuit or optical link 239 with light emitting means 241 and the detecting means 240. Furthermore, the machine is provided with a second optical link 242 with a second operative sensor means $S_{31'}$ 243. The second optical link may have light emitting means 241 in common with the first optical link but it may also be provided with separate emitting and detecting means, operating with a light wavelength deviating from that of the first optical link. The light emitting means are composed of optoelectronic components such as laser diode, IR-diode, UV-diode or visible light sources and the detecting means may include photo diodes or other light sensitive components. In simple designs the receiving means can also be composed of light signal means known in the art.

The hydraulic system of the machine and the process goods container is supervised by monitoring sensor means $S_{11'}$ 244 installed in a leakage-free bottom 245, to which also possibly occurring leakage hoses are connected, monitoring the tightness of inlet and outlet conduits or hoses (not shown in the figure). The monitoring sensor means $S_{11}$ is connected in series
with the operative sensor means S21 of the first optical link. The sensor means S11 can also consist of several sensors with the same monitoring function but connected, firstly, to the leakage-free bottom 245, and secondly, to leakage hoses pressurized by leakage liquid or non-pressurized. The sensor means S21, 238 comprises sensors operating in accordance with principles described in the foregoing.

Figures 36a and 36b show sensor embodiments operating in accordance with the principles described for the first group of sensors. The sensor of figure 36a is affecting the light transmission in the light guide 246 at pressure changes. This is brought about by the light transmission being blocked by two mutual, co-operating elastic membranes 247 and 248 affected by the liquid pressure in the household machine. At over-filling the pressure in the sensor housing increases and the membrane surfaces are pressed against one an another. Alternatively, the membrane or membranes can be provided with an edge cutting off the light beam, which allows extremely small light gaps and, consequently, bringing with it small light power losses in the sensor gap.

The sensor of figure 36b cuts off the light transport analogously by a moisture absorbing substance (surrounded by a solid tube) expanding upon absorption thereby being forced radially inwards until the normal space is blocked and thus also the light path. This sensor is designed for leakage supervision i.e. for use as a monitoring sensor means S11. A sensor according to figure 36d is provided according to the principles of the second group of sensor design. The circular-cylindrical sensor housing changes the light path in accordance with known physical laws at passage of the sensor housing. Depending on whether the housing is filled with liquid or gas (air) the light beam direction is changed, which is utilized for switching on or off the sensor function as desired.

Finally, figure 36c shows a sensor which is affected by the liquid pressure of the household machine. By with pressure, the reflection of incident light from the light guide is influenced, by deflection of the membrane caused by pressure variations. That of the pressure level dependent reflected light is caught by a second signal channel in the light guide.

Consequently, the described sensor principles and embodiments according to figures 36a to 36d admit that a suitable sensor choice can be done with respect to time constants, risk of contamination etc. for the household machine design illustrated in figure 34.
Figure 37 illustrates sensor and operating principles at installation of an optical link in a laundry washing machine. The figure illustrates in schematical form three operative sensors \( S_{31}, 270, S_{31}/S_{41}, 249 \) and two monitoring sensors \( S_{11L}, 250 \) and \( S_{11T}, 251 \). The first two sensors control filling of the collecting liquid volume at an analysis phase according to the first aspect of the invention. The sensor \( S_{41} \) is jointly associated with sensor \( S_{31} \) in a common housing, according to figure 38. The sensor \( S_{41} \) consists of a continuously operating sensor for measuring in a manner previously described the contamination degree of the laundry and rinsing liquids. The connection of the common sensor housing to the discharge arrangement of the laundry washing machine is such that the sensor housing is flowed through by the liquid which participates in the various operating cycles of laundering and rinsing. This occurs by utilizing the recirculation pump or other pumps, which are connected to the inlet 252 resulting in that the liquid passes sensor \( S_{31}, 254 \) designed in accordance with sensor principles described in the foregoing, after which the liquid is leaving the sensor housing at outlet 253. Light submitted from the light guide passes the light gap 254 at activation of \( S_{31} \) and is transmitted to the light emitting sensor surface 255, preferably by means of suitably distributed optical fibres. The contaminated washing or rinsing liquid causes light absorption, and the optical sensing surface 256 catches the attenuated, transmitted light, after which the signal is brought back by the optical link for determination of the soil contents. The sensors \( S_{31}/S_{41} \) are operating with signal conditions described in connection with figure 33. The sensors \( S_{11L} \) and \( S_{11T} \) constitute monitoring sensors for leakage and temperature, respectively, according to the above, for supervision of the temperature of the washing liquid and the laundry container 257. The sensor \( S_{11T} \) is operating in accordance with the first principle described above, of sensor design, i.e. with a divided light guide or fibre optic cable. The divided light guide can be displaced by a probing body 258, totally or partly, made of memory metal or bimetal utilizing temperature movements, and connected to the laundry liquid container 257, sensing the temperature in the region of the heating element. In order to avoid too high working temperature of the light guides made of plastics an insulation 259 can be fitted between the container and the probing body 258. The sensor design can be changed in such way that the probing body 258 is acting, by blocking, in the gap between the end surfaces of the divided light guide, thereby affecting the light guide transmission.
Figure 35 shows a practical embodiment of the first optical link according to figure 34. In the illustrated embodiment there is used a flow throttling-measuring device according to the third aspect of the invention with flow regulating and simultaneous measurement of the regulated flow, i.e. the means 235 and 236, of figure 34 is contained in a common housing. The light emitting and detecting means 260 and 261 is emitting and receiving respectively, light signals in accordance with the foregoing description. At stand-by or rest position the transducer, i.e. the component 262, as well as sensors S_{11} and S_{21} give free passage to the light, which means the monitoring sensor S_{11}, i.e. the leakage sensor, always assumes active monitoring status as long as optical power supply exists. Possible leakage during periods of no operation (for example during nights) is supervised continuously and when a leakage detected the safety-valve of the flow throttling-measuring device (not showed in the figure) is closed. By utilizing component 262 according to figure 35 the devices can be installed in the casing 263 of the household machine and in the leakage-free bottom 264 as illustrated by figure 40 and 41. Figure 40 shows the position of the component 262 and sensor S_{11} 265 when the leakage-free bottom has been provided with a suitably shaped cavity for collection of leak liquid. The optical link coincides in other respect with figure 28 and 34. Alternatively, the inlet hose can be surrounded by an open or closed leakage hose 266 and 267, respectively, as illustrated in figure 42 and 41. The leakage hose supervises the tightness of the inlet hose as well as the outlet hose. If leakage from any of the hoses appears, also an excess pressure appears in the lower point at the hose connection to the household machine, which is detected by the pressure sensitive optical sensor S''_{11}, 268, series-connected in the optical link with sensor S'_{11}, 269, which takes care of the internal supervision of leakage liquid collected by the leakage-free bottom. In this manner and as earlier has been described, an alarm or monitoring signal is obtained, which closes the safety valve of the component 262 (not shown in the figure). On the other hand if the component 262 is installed at the water mains connection point, leakage monitoring can be carried out by means of a sensor S_{11} in analogy with the foregoing by the leakage liquid being brought to the leakage-free bottom 264 by the pressure free, open leakage hose 266. The way of installation has the advantage that the inlet hose is only pressurized during the short periods of filling water into the household machine.
The methods and devices for carrying into effect the methods according to the second aspect of the invention are not restricted to the described embodiments but can be modified within the scope of the idea forming the ground for the invention.
A third aspect of present invention relates to apparatus according to the preamble of claim 13.

Valves are known where, in the flow path of the valve housing, immediately downstream existing valve seat or valve slide, a rotor carried in bearings has been inserted, the rotor being variously designed, e.g. as an axial turbin wheel or paddle wheel, indicating by its rotational speed the volume flow rate passing the valve device. Devices of this kind suffer from the weakness from the measurement point of view, that the flow field downstream the valve seat or valve slide is irregular and assymmetrical in relation to the rotor, where the degree of deviation will also be dependent of the adjustment of the valve, which in practical operation must always be adapted to the pressure prevailing upstream the valve, in order that a given flow (volume flow) be obtained. The valve rotor assembly will also be assymetrically loaded, with accompanying rapid wear, causing measuring error. The flow indication of this device is encumbered with great measuring errors, partly by different rotor blades having different angle of attack, partly by different valve settings causing different angle attack, both cases resulting in separation and losses along the rotor blades, devasteting to the measuring accuracy.

There are also known combined valves where the valve housing channels between valve seat and rotor and rotor and outlet have been provided with narrow passages in the form of hole series and narrow slots resulting in unacceptable pressure drops, clogging risks and the necessity of very exact manufacturing tolerances for holes and slots, both conditions incompatible with reliability in operation and low manufacturing costs.

Conventional flow meters are also known which operate with high or moderate measuring accuracy such, as turbine meters, winged wheel meters, vortex meters and meters operating with oscillating flow. However, a measuring condition for obtaining the higher measuring accuracy is that the meter be installed separated from disturbing components as valves, pumps and strainers.

Such flowmeters are designed to receive a flow, uniform upstream of the flowmeter, and having one-dimensional, usually turbulent velocity profile and to maintain this velocity profile within the flowmeter housing without flow throttling losses or separation losses until the flow reaches the inlet arrangements for example, vanes for the sensing element (turbine wheels, wing wheels etc.).

These necessary flow conditions are fullfilled by designing straight or curved channels with substantially unchanged cross-section area in the
flowmeter housing, and it is known that such channels have the capability to keep the flow, well-ordered and corrected already upstream the flowmeter, undisturbed while passing said channels, so that the inflow to the measuring chamber will take place with a substantially, one-dimensional velocity profile, where the angular momentum, decisive to the signal generating movement of the sensing element is only changing with the radial position of the fluid particles. In practice this adjustment of the flow means that it is necessary to install upstream and downstream the flowmeter straight, aligned tubes of the flowmeter size continuously joining the flowmeter inlet. Here, the straight length of the tubes should correspond to at least ten times the size of the flowmeter connection. Preferably arrangements of vanes should be provided in order to eliminate non-uniform flows and rotational movements in the flow, all together resulting in the necessary uniform inflow to and outflow from the meter. Furthermore, said flowmeter types provided with slide, ball or pivot bearings are sensitive to the strong vibrations occuring in machines of the type washing machines. To this should be added the influence of soil and deposits, affecting the cross-sectional areas critical to the fluid velocity, and causing bearing friction and installation limitation by a minimum back pressure value in the flowmeter outlet being specified, which several times higher than lowest water supply pressure that is desired where household machines are installed. Finally, the conventional flowmeter design means too high manufacturing costs to be acceptable in applications such as household machines. Thus, an object of the present invention is to provide a simple and reliable flow throttling-measuring device arranged in one joint housing for flow control and measurement of the regulated flow, control being carried out by flow throttling elements such as valves and volume flow regulators. A second object is to provide a device operating with a high measuring accuracy independent of the working position of the flow throttling elements, i.e. the adjustment of occuring volume flow regulators and/or valves, within a large inlet pressure range and down to very low inlet pressures, the device also being non-sensitive to external installation conditions such as connection hose design, accelerations and vibrations and the type of flow regulators used. Moreover, the device is to operate noiseless. Furthermore, it is a third object to provide a device having very low manufacturing costs in relation to functions obtained, and being adapted to
mass production of components for such application sectors as household goods techniques, heating and sanitary techniques and many others. A fourth object is to provide within the technical field of household machines, a device replacing a plurality of components which according to to-day's technical standpoint are necessary, such as water inlet valves, pressure sensing switches with associated pressure domes and over-filling protection equipment, by one device only, arranged in a housing whose geometrical measures and condition of installation are equivalent to those of the conventional inlet valve of to-day. A fifth object is to simplify of conventional components, such as water softening units for household machines and also to attain other new functions, such as monitoring the closing of valves and their tightness. Finally, a sixth object is to provide a device with flow measuring capability operating with an optical signal transmission circuit giving free light passage in stand-by or rest position of the device. Thus, the objects of the invention are obtained and the above-mentioned disadvantages related to known combined valves and measuring devices and flowmeters are eliminated by imparting to the device for flow control and quantity measurement of the regulated flow according to the invention the characteristic features defined in claim 13. The invention according to the third aspect of the invention is based on the discovery that the flow through in throttling elements generating a strongly disordered turbulent flow, such as valves, throttling channels and volume flow reducers (volume flow regulators) resulting in a deformed mean velocity profile of the flow, jet flows and rotational movements in the flow nevertheless can be transformed and controlled in smaller flow equalizing chambers adjacent the throttling elements, to assume the form of a desired predeterminable flow suitable for measuring purposes and resulting in a flow field with a velocity proportional to the quantity (mass, volume) passed, provided a stream room here for suitable, here called sensing zone, and connected to the flow equalizing chambers is formed in the housing of the device, said housing including upstream and/or downstream the flow equalizing chambers the above-mentioned throttling elements. This is possible irrespective of whether the flow throttling elements changing the flow are introduced upstream and/or downstream the sensing zone and in immediate proximity of the zone as long as the fluid before entering the sensing zone and flowing out therefrom is allowed to be influenced by the said specific flow equalizing chambers. The discovery is utilized in accordance with the characteristics of the
invention for creating of devices for flow regulation and simultaneous quantity measurement of the regulated flow. Figure 43 illustrates very schematically the chambers or stream rooms of which the device for flow throttling and simultaneous quantity measurement of the regulated flow are composed. The figure illustrates the general case with flow regulation both by volume flow control devices and by different valve means (all only diagrammatically shown) incorporated in the housing of the device at the inlet as well as at the outlet side of the device. In the housing of the device there are an intermediate chamber, a fore chamber and an after chamber, which are designated the first, the second and the third main chamber. In the chambers a continuous flow field with no distinct boundaries is developed upon passage of the fluid, where each zone of the flow field is dependent of the rest. Geometrically the flow field is divided, with respect to the operating principle of the area in view of the invention, into different zones, following one upon the other in the flow direction and designated valve zone I (inlet), inlet zone II, sensing zone III, outlet zone IV and valve zone V (outlet). The inlet zone II and the outlet zone IV are also designated flow equalizing chamber in view of the fluid mechanically mode of operating of these zones.

Figure 43a illustrates a fore chamber, i.e. the second main chamber connected to the supply conduit from the fluid source. This chamber encloses for the application in question the necessary number of sub-chambers. Usually, this means a sub-chamber for a volume flow reducer in the form of a straight forward volume flow regulator or check valve, respectively, valve means, such as electrically, mechanically or pressure controlled safety valves operating by direct acting as well as by pilot operated control or by a simple manual setting. The second main chamber forms the valve zone I (inlet).

Figure 43 e illustrates correspondingly the after chamber i.e. the third main chamber, connected to the second main chamber by the intermediate, first main chamber. The third chamber encloses in analogy with the second chamber the number of sub-chambers requested for the application. Normally this means sub-chambers for volume flow reducers in the form of simple volume flow regulators and valve means of the same design as those located in the second main chamber, that is, they are electrically, mechanically or pressure controlled, working by direct acting as well as by pilot operated control or by simple manual setting. Then the valves have usually the duty to regulate or open/close the passage area for a flow to a
process or to some other fluid procedure, i.e. they should be operative valves and not safety valves. The third main chamber forms the valve zone V (outlet).

Figure 43b, 43c and 43d show three geometrical zones or stream rooms located downstream the second main chamber and upstream the third main chamber and belonging to the intermediate, first main chamber which zones constitute together a geometrical form resulting in a flow field optimum from the standpoint of measurement, where proportionality between the tangential velocity and the flow rate (volume flow per time unit) is created spontaneously in the part of the first main chamber which is illustrated in figure 43c. The useful portion of the flow field in view of measurement extends also into the zone IV according to figure 43d.

Preferably in the zone III corresponding to figure 43c there is arranged a stationary or movable sensing element. In the latter case the element can consist of a free body or a body supported in bearing which is forced, by the velocity field in the zone III to perform a movement proportional to the mass or volume flow. A signal generated by the sensing element is recorded in a known way and most suitable way and the signal is transmitted in a manner likewise known to a control unit or signal processing unit co-operating with the device. The signal is carrier of information about flow rate as well as about passed quantity, i.e. volume or mass flow per time unit, and the total quantity that passed the device during a given time period. Thus, the geometrical zones in figure 43b, 43c and 43d form the first main chamber and are designated inlet zone II, sensing zone III and outlet zone IV.

Here, the inlet zone II according to figure 43b has the function, important from the from measurement point of view, to transform and smooth out in a fluid mechanical way the disorderly velocity distribution entering zone II, disintegrated and redistributed (into slot and jet flows) in the valve zone I under the action of volume flow reducers (flow limiting devices) and/or valves, thus obtaining a velocity profile usable from a quantity measurement viewpoint, said smoothing out meaning the creation of a velocity field which allows measurement in zone III, and this in all inlet pressure dependent working positions of the volume flow reducers and valves. Thus the inlet zone II will as described later, despite strongly, disordered flow conditions in valve zone I, distribute the fluid contineously and uniformly to the sensing zone III, so that in this zone a linear flow field will spontaneously appears. For this reason the inlet zone is also designated flow equilizing chamber.
Correspondingly, the zone IV has the function, important from the measurement point of view, to conserve fluid-mechanically the well-ordered symmetric and spontaneous flow created in the transition region between the sensing zone III and outlet zone IV, even when strongly, disordered flow conditions are created in valve zone V by influence of volume flow reducers and valves, as will also be explained later on in the description. Thereby the proportionality between velocity and flow in zone III, necessary for measurement reasons, is also conserved. For this reason the outlet zone IV is also designated flow equilizing chamber. Thus, in figure 44, 46 and 49 there is shown schematically the internal geometrical shape of the chambers of the flow throttling-measuring device according to invention in a first and second embodiment with respect to the outlet zone IV.

When seen in plane view, the second main chamber of figure 44 is defined by circular-cylindrical walls 300 and by means 301 introduced into the chamber. The first main chamber is defined outwardly by a wall 302 extending from the outset 303 of the inlet channel 329 along its outer wall in spiral form around the first main chamber, the centre of which is located in 0 and terminates at the inner side of the mouth 304 of the inlet channel, the spiral form preferably being logarithmic.

When seen in cross-section, as shown by figure 46, the first main chamber is defined by upper and lower, substantially plane-parallel end walls 305 and 306 and by side wall 302. The central portion of the chamber consists of the coaxially located outlet zone IV, which is determined by an outer body of revolution or an outer body having an internal surface of revolution 307 and by an inner body of revolution or inner body having an external surface of revolution 308, connecting to the sensing zone III, whose centre coincides with the centres of said bodies.

The stream room formed between wall 307 and 308 has a cross-sectional area as viewed in a radial section perpendicular to the axis 0, which preferably expands in the flow direction. Figures 46 and 49 show two alternative embodiments. That of figure 46 has a connection channel or outflow opening 309 between IV and V, centrally located, whereas that of figure 49 has a connection channel between zone IV and V located along the imaginary border surface 310. The outflow openings 309 and 310 to the valve seats form the geometrical border between zone IV and V, respectively.

An further geometrical boundary of the chamber between zone II and III is formed by a symmetrical, cylindrical surface, concentric with axis 0 and
zone IV, which touches approximately the inside of the inlet channel 304 at its mouth, said boundary surface being indicated at 311. In analogy herewith the boundary surface between zones III and IV is formed of a cylindrical surface 312, comprising an imaginary extension of the surface of body of revolution 307. Operation and the flow conditions when the apparatus according to the invention is connected to an uniform inlet flow 313 is illustrated in figure 45a. The fluid of the mean velocity \( \nabla \) is meeting a strainer 314, which in clean condition permits the fluid to pass uniformly over the strainer surface. An elastic disc 315, which is plane in unloaded condition and rests against cylindrical offsets or ribs 316, assumes a deformed condition determined by the inlet pressure causing deflection between the offsets or ribs, leaving a prescribed gap, or no gap at all, in relation to wall 317 for the fluid passage. Thus the flow regulated in this way will pass narrow gaps or slots, whose height measure \( h_1 \) 318 and \( h_2 \) 319 according to figure 45a are determined by the inlet pressure at the moment of regulation, the size of the gaps at any one inlet pressure varying in circumferential direction from segment to segment 320, 321 ..., see figure 45b, depending on the dimensions of the offsets or ribs. The result will be, firstly, that the fluid will pass through the segment openings 320, 321 ..., at different velocities and, secondly, that the velocity value will be dependent on the inlet pressure. In summary, this means that the fluid uniformly distributed when entering will reach the inlet zone II, in a strongly, disordered state, where different areas of jet flows can be identified. As shown in figure 45a strong formations of jets are formed in area 322 and weak ones in area 323, where each segment of the flow regulator device 324 contributes in correspondence to the offset or rib height. These jets are mixed with a central jet 325. This flow regulated in above-mentioned manner, obtains an inlet pressure working range 326 where the volume flow \( q \) varies with the inlet pressure in accordance with curve 327 in figure 50. For design and manufacturing cost reasons the inlet zone II, which receives the described disordered flow, often has to be given such a geometrical shape where connected to the valve zone I that there is added to the disordered flow described in the foregoing a region with recirculating flow 328 according to figure 44. As a matter of course valve zone I can be provided with volume flow regulators of other design which, however give as a result flow conditions comparable with those described above.
As to the fluid mechanical function of the inlet zone II, the invention is based on the discovery that this zone, in spite of the caotic inflow conditions, from measurement point of view is able to transform the fluid velocity and thus the momentum along a very short distance to a velocity distribution, which gives the desired conditions of inflow into the sensing zone III, so that first-rate measurement features are secured for zone III, implying that a very high accuracy of measurement is maintained over the whole working range 326 of the inlet pressure. This is achieved by suitable connection and shaping of the inlet channel of zone II, and by the fact that sensing zone III is surrounded by zone II, which means that the zone II, notwithstanding its geometrical proximity to the center of the housing, has a considerable longitudinal extension in the flow direction. Appropriate connection and shaping is obtained if the external wall 302, see figure 44 is made curved at least in a first direction (for example spiral-formed) with a substantially constant cross-sectional area in the inlet channel 329 and, for the remaining part of the inlet zone II, with a decreasing cross-sectional area in the flow direction. Thereby, the flow-through area of valve zone I is symmetrically connected to the cross-sectional area of the inlet channel.

In zone II the above described disintegrated and deformed velocity profile, generated in valve zone I is finally transformed to a form necessary in order that the following sensing zone, decisive in view of measurement, will generate the desired velocity field. Consequently, this means that the disintegrated and deformed velocity profile in a very short distance, successively and by influence of radial pressure and acceleration forces, well-adjusted and created in the inlet zone II and acting perpendicularly to the curved side walls and creating together by secondary flow and suitable wall friction, an exchange of momentum, said velocity profile is brought to convert into a hyperbolic distribution in relation to the centre of the sensing zone, which also includes uniformity in circumferential direction (angular symmetry). In other words, the inflow to the sensing zone III after passage of zone II takes place at substantially the same velocity and at substantially the same angle to a radius extending to the centre 0, along the imaginary interface surface 311 between zone II and zone III. The simplest total form of the inlet channel and the inlet zone leading to these inflow conditions is obtained according to above if the inlet channel 329 and the side wall 302 of the inlet zone II will exhibit, at least in some radial section perpendicular to of the axis 0 of the housing, a spiral form with
the greatest radial distance to the spiral from the centre 0 located at the connection of the inlet channel to the valve zone I, 303 and the smallest radius located at the inner wall of the inlet channel 304. By the spiral form of the side wall, i.e. its curved surface, the secondary flow will act vigorously in zone II on the flow deformed and disintegrated in the valve zone I at the same time as the fluid flowing in zone II due to the shape of this zone tapering in the flow direction, is caused at prevailing wall and fluid friction, to pass the interface surface 311 at substantially the same velocity and at substantially the same angle to a radius extending to centre 0. These geometrical conditions agrees with the geometrical form of the logarithmic spiral, for which reason the side wall is preferably formed this way for low-viscous fluids.

Furthermore, the invention is based on the discovery as to the outlet zone IV and the valve zone V that the flow in zone III can be maintained with unchanged first-rate measurement features even when bodies of revolution 308 and 307, respectively, see figure 49, externally and internally symmetrical in respect to the vortex centre are inserted into or connected to the vortex field, as long as the flow along the walls of the bodies remains rotationally symmetric with regard to the vortex centre and, consequently, substantially disturbance-free.

The discovery implies that the bodies of surface of revolution can be shaped individually or together in such way that the walls form a compact stream room or channels connected to chambers of valve zone V, rendering it possible to locate the valve zone V in the immediate geometrical proximity of the zone III.

By generating optimum conditions of inflow to the sensing zone III along the total interface 311 between zone II and III, in spite of the adjacent valve zone I integrated in the housing of the device, and by optimum conditions of outflow from the sensing zone III to the outlet zone IV, said conditions created in outlet zone IV, with well-adapted and uniformly acting velocity, pressure and shear stress conditions acting along the imaginary interface 312 between zone III and IV in spite of the adjacent valve zone V integrated in the housing of the apparatus, there is generated for fluid mechanical reasons, comparable with the operating principles of flow meters provided with a vortex chamber, a flow field in the sensing zone III of the housing where the tangential velocity of the fluid is proportional to the volume flow (flow rate) in this, annularly shaped, vortex chamber whose central portion encloses the valve zone V.
For the annular vortex chamber illustrated in figure 49 it is true that the presence of the walls of the valve zone V means that the fluid is brought to stand still at chamber radius $r_{IV}$, which means that there is a reaction on the tangential velocity $v(r)$ in zone III. However, by adapting the radius $r_o$, $r_{ut}$ and $r_{IV}$ in proved way at given flow rate $q$ and chamber height, together with observing the above-mentioned inflow and outflow condition at zone III, a such velocity field can be created in zone III in the case of an annular vortex chamber that the tangential velocity $v(r)$, prevailing at radius $r$ within zone III, will constitute a multiple of the tangential velocity $v_o$ prevailing along the imaginary interface surface 311 between zone II and III, i.e.

$$v(r) = \text{constant} \cdot v_o$$

This can be explained by the fact that the relationship $v(r)/v_o$ is not notably changed at a given radius $r$ in zone III at a sufficiently high value of the Reynolds number calculated with regard to radial velocity and the radius at the interface surface 311 for the fluid in question. However, by the inlet zone II fluid flow transformation and essentially uniform distribution of the fluid of volume flow rate $q$ along the interface surface 311 according to above, the velocity $v_o$ will be proportional to $q$, which leads to the above-mentioned relationship of for the tangential velocity $v(r)$ and the volume flow rate $q$, i.e.

$$q = \text{constant} \cdot v(r)$$

However, the radius $r$ with the corresponding tangential velocity $v(r)$ is the designation of an arbitrarily selected radius within the zone III and hence the relationship is applicable to any radius within zone III, i.e. the linear relationship between $v$ and $q$ is true for the whole of the zone III. The operating principle and the flow pattern in zone IV in relation to the flow field in zone III and V are illustrated in figures 46 to 49. Thus, according to the above the basic measurement condition resides in the feature that the flow conditions in zone III is not to be influenced by the disordered flow conditions arising downstream in valve zone V when the flow is regulated by volume flow reducers and valve means.

If separation and flow instabilities appear, which have been illustrated by region 331 in figure 49, as a result of unfavourable flow conditions in zone IV and/or unsymmetrical load of zone IV by sub-chambers for volume flow reducers and valves which for design reasons have been suitably located in zone V the primary flow can be affected as shown in figure 49, bringing with it that the vortex field is displaced and/or tilted as indicated by lines 332 and 333, respectively, in figure 49. This means
that desirable, symmetrical velocity, pressure and shear stress conditions along the the interface surface 312 are lost resulting in corresponding degree of deterioration of measurement features. The changed position of the vortex centre means that the relative position of the sensing element is changed in the vortex field and propelling and retarding forces, decisive to the measurement accuracy are affected. If a sensing element in the form of a freely, movable ball is chosen as an example, said ball being guided in circumferentially direction in mutually opposed grooves concentrical with the outlet, the ball will repeatedly pass through sectors having different radially pressure drop acting over the ball surface and being affected by a propelling force varying with the varying tangential velocity in the sectors.

The tendency towards instabilities and separation in zone IV is dependent on the change in tangential velocity and pressure in radial direction and thereby in the flow direction. It can be showed that stable, basic pre-conditions are present when the angular momentum and pressure decrease with decreasing radius and in the flow direction i.e. when the flow takes place according to figure 47, which illustrates the paths of fluid particles in a radial section through zone IV and V of figure 46, a condition utilized in the practical embodiments of figures 51 and 56. On the other hand, if the outlet zone IV is shaped in such way that the angular momentum decreases and the pressure increases with increasing radius and in the flow direction i.e. when the flow takes place according to figure 48, which illustrates in a corresponding manner the paths of fluid particles in a radial section of zones IV and V according to figure 49, a careful adaption of pressure gradients generated must be carried out in order to avoid disturbances in the form of separation.

A practical embodiment of this geometrical shape of the outlet zone IV is shown in figure 58. The risk of separation is also dependent on the curvature of the walls 307 and 308. At a given ratio between the tangential velocity and the axial velocity in the inlet to zone IV, herein referred to as swirl ratio determined by the flow conditions which as to be maintained in zone III, in order to get best linearity also the axially pressure gradient acting along the walls 307 and 308 is determined, at a given curvature. This axial pressure change affects the risk for separation. Thus, by varying the curvature at a given swirl ratio the separation risk can be affected. By the swirl ratio also the separation risk or the position of the separation point/area can be influenced by way...
of the boundary layers along the walls 307 and 308 by transport of momentum between said layers and the primary flow.

For example, the desire to attain an effective pressure recovery in zone IV by a strongly expanding flow through area can give rise to separation. This condition can be controlled by increasing the swirl ratio in a manner described above, a possibility utilized according to the invention and leading to the possibility that devices according to the invention can operate with extremely low inlet pressures and with high measurement accuracy, an installation condition which is particularly important for household machine applications where water supply systems in residential housing and secondary homes in rural areas usually give low supply pressure. Furthermore, the swirl ratio affects the flow pattern in zone IV in such manner that at swirl ratios of current interest the fluid seeks spontaneously to perform a swirl motion with an axially return flow in the centre of the vortex field, which together with the tangential velocity of the fluid surrounding the the outlet tube of valve zone V, leads to very favourable conditions of inflow to the outlet tube i.e. to a minimum of losses.

The described possibilities flow of regulating at simultaneous quantity measurement of the regulated flow also gives the technically valuable feature that the operation principle of the device permits a considerably extended working range for the inlet pressure with a high measurement accuracy compared with a corresponding conventional flow meter, in all meaning that an improved measurement accuracy is reached.

This can be seen from figure 50, where diagram 335 shows the flow regulating characteristic 327 achieved in the above-mentioned manner whereas curve portion 336 indicates the conditions in zone III, i.e. the variation of the instrument constant $K_R$ as a function of the flow rate $q$, in other words accuracy of measurement of the device. The instrument constant is expressed in this connection as the number of electronic pulses per volume unit which passes the zone III, for example, the number of revolutions which a movable sensing element located in zone III is performing per volume unit of passed fluid. In an equivalent way figure 50 shows the measuring conditions for a conventional flowmeter of corresponding size and design, i.e. a device without any volume flow reducer in the inlet. The flowmeter is supposed to be installed with a connecting pipe continuously joining the flowmeter inlet and provided in the flowmeter housing with a curved channel with no sections of flow throttling elements in the flowmeter housing. Already at an inlet pressure
of about 0.1 MPa (dependent on prevailing back pressure) the flowmeter has reached, in the latter case, the maximum volume flow rate allowed, meaning also that the maximum error specified for the flowmeter has exercised influence on the measurement result within the working range 337 of the inlet pressure.

In a flow throttling-measuring device according to the invention the flow rate is limited according to the curve 327 and within the normal working range of the inlet pressure, e.g. 0.1 MPa to 1.0 MPa, the sensing zone III will operate with small variations in the velocity at pressure changes, implying a minimum of measurement errors, especially as zones II, III and IV are adapted to give the best measurement features within the limited working range 336 of zone III. In summary, this means that the flow throttling-measuring device can be installed in all normal water supply systems with unchanged high accuracy of measurement and without risk of overloading the device.

From a practical point of view the transformation influence on the flow of the inlet zone II has also the important effect that the upper maximum working point, determinated by the volume flow reducer 324, can be changed for the same size of the housing of the device without any influence on the instrument constant $K_R$. The effect of the changed jet and slot flows in zone I when exchanging of component 324, figure 45a, in the same housing of the device according to the wishes of the users or service staff is eliminated in zone II and the tangential velocity in zone III is not affected. Thereby the instrument constant is also kept unchanged and the accuracy of measurement is not affected. The same result is also obtained in different design of the connection unit of the cylindrical inlet 338 of the housing. See figure 45a. The instrument constant is not affected if a connection unit of straight or knee type is used when installing the household machine.

The above mentioned flow conditions illustrated in figure 43 to figure 50 will be explained in greater detail with reference to the practical embodiments, shown in figures 51 to 71, which now will be described by way of example. Figure 51 to figure 71 correspond to the application sector household machines, while figure 72 represents an embodiment adapted to thermo-technical components. Thus, figure 51 and figure 52 show an apparatus for flow regulation with simultaneous volume measurement of the regulated flow in a practical embodiment, adapted to household machines, such as dishwashers and washing machines. The flow throttling-measuring device, designated the component in the following, is provided, in view of
its normal use, with both flow rate regulator and shut-off valve.
The valve is a pilot operated membrane valve, controlled by an
electromagnet and the component is shown in its straightforward design
with only one outlet.
In agreement with previous description the component 345 is divided in
three main chambers, of which the first comprises the inlet zone II,
sensing zone III and outlet zone IV. The second main chamber comprises
valve zone I and finally the third main chamber comprises valve zone V.
The cylindrical inlet 346 including the second main chamber and with a
size of connection adapted to prevailing practice, is enclosing the valve
zone I according to figure 51 and is provided with a strainer 347 and a
volume flow reducer in the form of a volume flow regulator 348. The
circular-cylindrical chamber of the valve zone I can also be provided with
check valve means when the flow rate regulator 348 in view of available
space is located in valve zone V, i.e. in the outlet tube 349, preferably
within the dashed area 350. The function of the flow rate regulator is
based on changed flows in slots or gaps caused by pressure and fluid
dynamic forces acting upon an elastic, deformable membrane 351 (e.g. rubber
plate). By this volume flow restriction an approximate regulation can be
maintained in accordance with the previous description, at least at higher
pressure. A strainer or inlet filter introduced into the valve zone I
prevents larger particles from accompanying the liquid into the liquid
container of the household machine.
The cylindrical inlet is connected to a housing 352 containing the first
and the third main chamber, which is composed mainly of a bottom or lower
portion wall 353 forming a cover, including the outlet tube 349 of the
valve zone V, which tube projects into the first main chamber of the
housing and of a top or upper wall partition 354, containing an axially
disposed chamber 355 concentrically with the outlet tube constituting the
outlet zone IV, 356, and a control chamber 357 for the pilot operated
membrane valve 358. The outlet zone IV, 356 and the control or pressure
equalizing chamber 357 is separated by an elastic diaphragm 359 which is
provided with two holes 360 and 361 according to figure 54 (showing a part
of the membrane on a larger scale) and influenced by a plunge or disk 362,
whose position is controlled by the electromagnet 363 by way of a coil.
Upper and lower wall portions are mutually parallel and maintained at a
determined distance apart by means of a spiral-shaped wall, the side wall
364 (see figure 52). Bottom 353, top wall portion 354 and side wall 364
define together the first main chamber having a tangentially directed
inlet 365 and a central outlet 366 arranged concentrically with the outlet tube, forming inlet to said outlet zone 356. The inlet channel 367, constituting a part of the inlet zone II, may have of a rectangular or square cross section and is adjusted to the side wall 364 of the spirally shaped inlet zone and to the other walls of the chamber so as to avoid that abrupt changes of the cross-sectional area appear, whereby a fluid can be introduced into the chamber after transformation (redistribution) in the inlet channel of the generated gap and jet flows in the volume flow regulator without disturbing losses caused by area changes. The side wall 368 of the inlet channel is spiral-shaped and constitutes an extension of the spiral-shaped side wall 364 of the chamber. The cross-sectional area of the inlet channel is approximately constant but is adjusted in order to be best connected to the channels of the cylindrical inlet (i.e. the channels of valve zone I) after the volume flow regulator. In the walls of the inlet channel, preferably in side wall 368 an adjustable spring loaded tongue can be fitted for compensating geometrical variations in the dimensions of the housing related to manufacture.

In accordance with the aforesaid the first main chamber is divided into an inlet zone II, a sensing zone III and an outlet zone IV having a common centre at 0, the border between the two first mentioned zones being formed by a cylindrical surface 370 arranged concentric with the zones and having a radius corresponding to the distance between the centre 0 and the radial inner edge 371 of the inlet channel. The border separating the sensing zone III and the outlet zone IV is in the form of a cylindrical surface 372 which is formed by an imaginary extension into the first main chamber of the smallest radial cylinder surface of the outlet zone. The border defining the inlet zone outwards is formed by the spiral shaped chamber wall 364, which extends along a spiral, preferably logarithmic, and starts from the radially outer edge 373 of the inlet channel and extends about 360 around the chamber and terminates at the radially inner edge of the inlet channel. The pitch of the spiral coincides substantially with the width of the inlet. For practical reasons, the inner edge of the inlet channel can be displaced forward or backward in the direction of the inlet channel without inconvenience.

As previously stated, the logarithmic spiral shape of the chamber will enable that the basic operational condition for the inlet zone be fulfilled, namely, that the speed at which the fluid flows into the sensing zone III is substantially the same throughout and takes place in a direction which forms throughout substantially the same angle with a
radius to the centre 0 of the chamber. It should be mentioned, however, that these conditions can also be fulfilled in practice with other spiral forms adapted to the friction (viscosity and wall friction) of the flowing fluid. Further, the sensing zone is defined by the two wall portions 353 and 354, which are preferably located in parallel planes, in a manner such that the distance between the wall portions can be altered stepwise with respect to design and size of the sensing element 375 and to the shape of the outlet zone. The wall portions can also form a certain angle with each other without reacting negatively on the operation of the component. The valve operation of the component is obtained by the upper opening 376 of the centrally located outlet tube 349 forming a valve seat 377 and the sealingly fitted elastic diaphragm 359, operating from the opposite side in relation to the end of the outlet tube, said diaphragm position being controlled by the electromagnet 363 of the component, the switching on/off of the magnet causing either deblocking or blocking of the outlet tube, i.e. opening or closing of the membrane valve.

The elastic diaphragm being of known design, separating the control or pressure equalizing chamber 357 from the upstream side i.e. outlet zone IV. By a smaller, well-defined, excentrically placed hole 360 or by a concentric series of holes the control chamber communicates with the flow chamber of the upstream side and by a central placed hole 361 with the outlet tube.

The central hole in the elastic diaphragm can be blocked by a plunge or disk 362 corresponding to the hole, said disk being actuated by a light spring force and controlled by the pulling force of the electromagnet 363. By closing the central hole the pressure of the upstream side will be effective over the entire diaphragm surface and displace the diaphragm to make contact against the valve seat 377. By deblocking the the central hole the pressure in the control chamber will be drained off to the outlet tube 349 and the diaphragm will be displaced in the opposite direction and the valve seat uncovered. In this way the component according to figure 51 will bring about, at energizing and de-energizing of the electromagnet, opening and closing, respectively, of the valve of the zone V in the same time as an accurate flow quantity metering can be carried out during the open period.

The invention is in no respect limited to the described valve design but can be modified in a desirable way to obtain opening and closing of the outlet tube as well as regulating of the flow through the valve.
For example, by replacing the above mentioned pilot operated membrane valve with a direct operated valve, working against valve seat 377 in an analogue way the measuring accuracy of the component is increased at filling of very small quantities by essential reducing of the time constant for the component (from about 2 seconds to 0.5 second).

The exterior wall 378 of the outlet tube forms also a fluid mechanical stabilizing, inner boundary of the outlet zone IV, implying that thanks to the location and the symmetrical form of the tube in relation to the vortex field of the sensing zone, the symmetry is preserved in the outlet zone IV, in as regards velocity-, pressure- and shear stress conditions in respect of the vortex centre. By suitable choice of friction conditions and dimension of the outlet tube in relation to the radius of the sensing zone and the outlet zone the proportionality between the tangential velocity and the volume flow in the sensing zone is maintained as previously explained in connection with the flow conditions of zones III and IV. Velocities and kinetic energies created in the sensing zone III are converted in the outlet zone IV to values adapted to give undisturbed (oscillation and separation free) and symmetric outflow, free of losses (dissipation losses) to the extent possible. This takes place by having the swirling flow generating a momentum exchange between the primary flow of the zone IV and the boundary layer flow along the walls of outlet zone IV and by the fact that the auxiliary body, which in this case is formed by the exterior of the outlet tube, together with the other walls of the zone IV, affect the flow and contribute to desirable pressure distribution in the flow field, creating acceptable pressure change along the walls of the zone IV. Symmetric undisturbed swirling flow is in this way established and separation in the outlet zone with accompanying influence on the primary flow in zone IV as well as zone III is counteracted, at the same time as favourable inflow conditions to the outlet tube 349 occur and is maintained in the whole working range. Thereby the high measuring accuracy of the component is also maintained, in spite of the proximity to the sensing zone of the valve zone V, i.e. the proximity to the valve seat.

The flow process means a maximum of pressure recovery in the outlet zone IV, which serves as a conical, axial diffuser dimensioned for the swirling ratio in zone III, which is determined of the measuring technical conditions stated for zone III. The component according to invention will in this way operate with its measuring accuracy retained also at very low pressure, as distinguished from to conventional flowmeter designs. An inlet pressure of about 10 kPa (0.1 bar) of the component is sufficient, which
give an essential advantage in applications of household machine, where available water supply pressure often constitutes a limiting factor for installation of the machine. The centrally located body in the centre of the vortex chamber will also contribute to an efficient degasing of the housing, due to the fact that released gas follows the outer wall of the body, directly guided into the flow field surrounding the inlet of the outlet tubes. This implies that the body can be utilized for enclosing a gas detector or air sensor.

The embodiment illustrated in figure 51 to 53 shows the sensing element of the component in the form of a ball 375, which is guided by rolling contact surfaces arranged in the housing upper and lower wall portions 353 and 354. These surfaces can be designed as one or two shallow grooves concentric with the outlet zone, whereby, in the case of one groove the opposite rolling contact surface has the shape of a flat rolling contact surface. The ball lightly engages the groove or the grooves and follows the same circular path in the sensing zone III of the first main chamber, activated by the passing fluid circulating within the zone. The speed of the ball or its orbiting rate, i.e. the number of revolutions of the ball per time unit, thus offers according to the invention a very high degree of accuracy, and also reproducible linearity of the flow parameters of the fluid passing the sensing zone, such as passed quantity per unit time. As previously mentioned, by summing the total number of orbiting revolutions information is obtained about the total quantity of fluid, which has passed the component during the flow regulated measuring period, i.e. during a measuring period corresponding to opening and closing, respectively of the solenoid valve. With flow parameters are here meant the physical magnitudes which are normally of interest with respect to flowing fluids as liquid, gaseous or multicomponent media, commonly designated fluids in the description.

For detecting the ball movement, primarily the total number of orbiting revolutions and/or orbiting rate several known methods are at disposal, such as, inductive, magnetic-inductive, optoelectrical/ fiberoptical etc. The fiber optical arrangement is shown at 380. The signal generated in this way by the component is transmitted in known manner to a signal processing unit or signal converter of optional type operating according to known methods. By means of a simple electronic compensating operation of the signal generated by the component, the accuracy of the component can be further raised. In order to ensure free light passage, in the case of an optical signal transmission, in e.g. a monitoring system, during
periods of measuring inactivity, it is sufficient to tilt slightly the housing to raise the point where light passage occurs in the sensing zone. If suitable the grooves can be supplied with a smaller cavity ensuring that light transients in the flow do not move the ball. If external mechanical blocking of the sensing element is desired, the first main chamber can be provided with, for example, a solenoid valve or some other flow controlled means, acting upon a pin or tongue, displaced into the chamber upon a control signal.

The low manufacturing cost of the component is attained by the fact the flow metering principle according to previous description permits to be utilized simple detail design and inexpensive material. Consequently, the rolling contact surfaces for the ball can, according to figure 53 be done-plane causing a low machining cost of the rolling or guiding detail, also of guiding materials of higher quality and hardness. The lower rolling surface or guiding detail with a more expensive elaboration concerning machining permits thereby a manufacturing in softer materials of lower quality i.e. to a lower detail cost. This combination of material properties of the rolling contact surfaces will also make it possible to use a ball manufactured of glass, with high measuring accuracy maintained, which together solves the problems of manufacturing cost of the required ball and the guiding details. If inductive or magnetic-inductive sensors are used for sensing the ball passages, as indicated above material and material properties can be reversed as far as the ball and the plane guiding detail are concerned. In this manner necessary material properties of the ball are obtained for the pick-off design. By permitting the rolling contact surfaces to introduce a certain distance from the upper and lower wall portion, i.e. the end walls of the sensing zone III according to figure 53, under interaction with the adapted flow field in: outlet zone IV suitable influence on the primary flow from the boundary layer flow along the upper and lower end walls can be achieved, resulting in improved measuring properties i.e. to reduced error in linearity of the component at the same time as the ball size can be reduced for a given component size, i.e. for a maximum flow rate of the component. The latter circumstances lead to further reduction of the valve component manufacturing cost.

Furthermore, a low manufacturing cost is possible to obtain by simplifying the design of the housing of the component. This is above all applicable to the design of the outlet zone.
Dependent on manufacturing cost acceptable for the application a compromise can be done between the technical performance data of the component and the optimal wall shape of the zone IV. Figure 61 and 58 exemplify a low and high cost embodiment, respectively, of the design of the outlet zone. The the outlet zone IV and the valve zone V are provided with cylindrical, non-conical walls 390 and 391 in the low cost alternative according to figure 61 and 63, in order to permit lower tool cost. Also in the low cost embodiment dimensions of the outlet zone are chosen as far as possible, in agreement with the best fluid mechanical shape. In this way also here symmetrical inflow to zone V is obtained with a certain degree of pressure recovery. At maximum of simplification: the central body of revolution is entirely left out. However, an outlet zone with cylindrical walls can also be improved at low cost by providing the same with a separate, co-axially, placed tube according to figure 64 and 63, preferably conical and mounted concentrically with the sensing zone, opening into a cylindrical chamber provided with valve seats.

Thus, the simplicity of the flow rate or volume measurement principle contributes to a very low manufacturing cost of the valve component at the same time as high measuring accuracy is obtained. This means that the filling accuracy, specially at small volumes, can be improved more than 10 or 20 times compared to traditional technique applied within the sector of the household machines. As has been illustrated in figures 55a to 55c, all showing an axially section through the centre of the first main chamber, the sensing element can be given both different shape and location in relation to the valve zone I and valve zone V of the component. Figure 55a shows an embodiment with a rotor mounted in bearings, while figure 55b shows an embodiment having a freely moving, cylindrical roller guide in two grooves concentrically with the outlet. Figure 55c shows the sensing element, in form of a ball, located in the outlet zone, while figure 55d illustrates a rotor 381 where the height of the rotor exceeds the height of the chamber in zone III and where the rotor shaft 382 is mounted in bearings, carried in the wall 383. For improving the inflow and outflow, flow guiding channels can be introduced at 384 and 385.

The flow transformation in the inlet zone II of the velocity distribution of the flow, created in the valve zone I, unsuitable from the measuring standpoint according to previous explanation, can also be effectuated by means of a pre-chamber 386 arranged in the inlet zone II, uniformly distributing the fluid around the circumference of the sensing zone by
means of a concentrically located body 387. Here a series of channels or guide vanes 388 are responsible for ensuring a uniform inflow to the sensing zone, i.e. inflow at substantially the same velocity and direction throughout the peripheral surface of the sensing zone. A component according to this second embodiment of the invention is illustrated in figures 61, 62 and 63. Thereby, figure 61 shows an axial section through the centre of the component, parallel to the outlets, whereas figure 62 shows a radial section through the first main chamber of the component, i.e. the zones II, III and IV. The sensing element is made up of a ball 389 propelled by the flow in zone III and circulating around the outlet zones IV, positively guided by rolling contact surfaces as previously described.

The walls 390 and 391 of the outlet zone according to figure 63, showing a radial section through the zones IV and V, are made, for manufacturing cost reasons, substantially parallel with the central axis of the housing, necessary tool clearance angle being allowed at manufacturing. The inner wall is circular-cylindric, while the walls 390 and 391 are shaped in suitable spiral form according to figure 63 to merge smoothly with the walls of the housing and the sub-chambers 392 of the valve zone V, each sub-chamber enclosing a pilot operated membrane valve, as of earlierly described with reference to figure 51.

In several applications where the component is used, for example in washing machine installations, a component is necessary which is provided with several outlets.

An embodiment with three outlets is shown in figure 56 with, outlet dividing angle $120^\circ$ for obtaining the best flow symmetry in the outlet zone IV of the component. The component is composed of three main chambers, whereof the first main chamber comprises, in a way corresponding to that earlier described, an inlet zone II, a sensing zone III and an outlet zone IV. In the same manner a valve zone I and a valve zone V, respectively, are found in the second and third main chamber. The component is shown in figure 56, details in the valve zone I and V being removed for the sake of simplification.

The upper part of the of the component, comprising valve zone I and inlet zone II, sensing zone III and part of outlet zone IV has been formed in the same way as has been described with reference to the embodiment figure 51. This means that the component has a cylindrical inlet 395, provided with suitable volume flow limitation means, said inlet being joined to the housing 396. This being mainly composed of a lower wall portion 397 and an
upper wall portion 398, which are spaced a predetermined distance by means
of the side wall 399 which, in correspondence to figure 51 embodiment the
previously described, has been given spiral form to secures suitable
inflow conditions to the sensing zone III from the inlet zone II. The
first main chamber is provided with a sensing element in the form of a
ball 400, which is orbiting concentrically with the outlet zone IV, under
the action of the fluid and guided by rolling contact surface 401 and 402
located in the wall portions as previously described.
The outlet zone of the component consists of a body 403 having an external
surface of revolution and a body 404 having an internal surface of
revolution, both concentric with the common centre O of the sensing
zone. The body 403, which can be cylindrical, extends from the upper wall
portion 398 into the stream room of the outlet zone IV, formed between the
surfaces of revolution, said body 403 leaving a fixed distance to disk 406,
which is provided with a central hole 407, and whereat said disk axially
restricting the outlet zone IV and axially separating the outlet zone IV
from the valve zone V. The outlet zone is communicating with the valve zone
V through the hole 407. The body 404 of the outlet zone having an internal
surface of revolution has slightly curved or conical walls giving a
stream room expanding in the flow direction. The valve zone V is composed
of three sub-chambers 408, 409 and 410 located symmetrically angularly
spaced of 120 about the centre O and at a given radial distance therefrom.
The sub-chambers are provided with a pilot operated membrane valve,
solenoid controlled as described with reference to figure 51. Thus, the
sub-chamber is divided by the diaphragm into a control or pressure
equalizing chamber and an upstream region, communicating with hole 407 in
disk 406 via substantially plane-parallel, curved diffusers or channels,
located in a radial plane perpendicular to the axes O of the surface of
revolution and axially between the disk 406 and an end wall 412, forming
lower wall portion for the valve zone V. Each of the sub-chamber, inwardly
circularly formed, is provided with an outlet tube 413, with the
sub-chambers concentrically fitted in, said outlet tube being provided with
an outlet 414, curved 90 to open in a radial plane in a direction suited
to the use of the component. The sub-chambers are exteriorly provided with
suitable fastening arrangements for the solenoids. Furthermore, the body of
surface of revolution 404 and the upper wall portion of the housing 398
have a fibre optical light guide attached a suitable angle to sense the
movement of the ball 400 in a way earlier described. The component can ci
course be provided with an optional recording system for sensing the bell movement.

The fluid entering the inlet passes the valve zone I and the inlet zone II as earlier described with reference to the figure 51 embodiment, i.e. in such manner that the inflow to zone III occurs at substantially the same speed and at substantially the same angle with respect to the imaginary boundary surface between zone II and zone III. This means that the flow changes uniformly and continuously from a flow field of character "free vortex flow" to a flow field of character "forced vortex flow" when the fluid is passing into outlet zone IV. This shear stress dominated pressure and velocity distribution, with the kinetic energy substantially linked to the tangential and axial velocity, defines, consequently, the fluid state prevailing in the upper part of zone IV, after which the flow, under influence by the wall 415 of zone IV and the wall 416 of the central auxiliary body, is brought into a monotonic slow down process. This is obtained by adapting the curvature of the walls in such a way that pressure distribution along the walls determined by the primary flow will not, at prevailing swirl ratio and momentum transport to and from the boundary layers, cause separation when fluid passes the axial stream room with accompanying pressure increase in this space. By choosing a conical stream room chosen according to figure 56 and by forming the outlet zone IV so that a radial flow inwards exists when fluid passes to zone V, which according to the foregoing reduces the risk of boundary layer separation, this negative process for the measurement features of zone III is avoided. Thereby, also the outlet zone IV will be designed such that a substantially unchanged flow is conserved in the sensing zone irrespective of outlet used. The flow in the lower part of the zone IV is, subsequently, determined by the disk 406 with its central outflow hole, which also may be completed with a short tube projecting into zone IV and V. The dimensions of the central hole and of the plane, curved diffusers placed downstream in zone V are chosen such that the lowest possible pressure drop is generated, whereby the pressure recovery in the axial part of zone IV is best utilized. Finally, the flow passes that or those valves which are open for the moment, whereby a measurement procedure of afore-mentioned kind can be conducted during flow regulation.

In figure 58 there is shown an alternative design of the component, here provided with one inlet and three symmetrically positioned outlets. The upper part 420 of the component, thus comprising valve zone I and inlet zone II, sensing zone II and part of outlet zone IV, is identical
with the upper part 396 described with reference to figure 56. The outlet zone has in this case been shaped such with regard to the centre 0 by means of the body 421 having an external surface of revolution, and the body 422 having an internal surface of revolution that the flow in the outlet zone permanently takes place in a radial direction outwards i.e. with increasing pressure and decreasing moment of momentum in the flow direction (destabilisation conditions). The outlet zone IV communicates with valve zone V through the stream room 423 between the bodies 421 and 422, which is expanding in axially and radially direction without any intermediate wall, by continuously connecting the stream room 423 to the sub-chamber 424 of the valve zone, designed and fitted into the wall portion 425 of the valve zone according to the description with reference to figure 56. The end wall 425 is hereby formed as a cover united with the intermediate detail 426, which lies axially between the upper part 420 of the component and the cover 425. The detail 426 can be provided with partition walls 427 for best guiding the fluid to the outlet tube 428 and the outlet 429. The structure of the partition walls is illustrated in figure 59, which shows a half radial section through zone IV and V in the dividing surface between details 426 and 425. The fluid entering the inlet is passing the upper part of the component according to the previous description. To maintain undisturbed passage of zone IV and thereby keep first-rate measuring features for zone III, the velocity and pressure distribution is adjusted by means of the curvature of the body 421 and the wall 430 in such way, that the in surface pressure variation along the convex wall determined by the primary flow in zone IV, is lower than an empirically determined maximum value at prevailing swirl ratio and momentum transport to the low energy boundary layer along the wall 430. In a corresponding manner the flow conditions of the lower section of the body 421 may be controlled, where additional pressure load acting on the flow can be generated by introducing vanes 431 when necessary.

Figure 65 shows an embodiment of the component where the valve zone I has been provided with two cylindrical inlets 435 and 436 of a design described earlier, forming an angle with each other, provided when necessary with suitable flow rate reducers. Furthermore, the figure shows an additional inlet 434 which has been provided by way of example with a straight forward hose connection, connected to a smaller vortex chamber 440, described below in greater detail.
The inlets 435 and 436 are provided with sub-chambers 437 and
438, respectively, comprising pilot operated membrane valves, also described hereinbefore. The cylindrical inlets communicates with zone III belonging to the first main chamber of the component, through the inlet zone II, which has been extended in order to connect also to the sub-chamber 438. In this way switching between supply flows can be carried out, also rendering it possible to measure both volume flows without installing additional components.

By providing wall portion 439 with a second vortex chamber 440 integrated in the end wall designed in accordance with the invention, but rated for small flows, a further solution is obtained bringing with it a large operating range in respect of flow rate. Figure 66 shows a possible location of a smaller, first main chamber 440 which permits use of the same recording system 441 for both volume measurement devices included in the common housing. In this way the manufacturing cost calculated per measurement operation is further reduced. The smaller first main chamber is supplied in analogy with the component according to figure 51, with a sensing element in a form of a small ball, guided in grooves and orbiting the outlet zone IV, which can be connected to a valve zone V (not shown in figure).

The operating range of the component, the dimension of the first main chamber given, can also be influenced by providing the component with a by-pass channel between inlet zone II and outlet zone IV.

Household machine installations usually require multi-arrangements of leakage protection, where the different safety systems operate independent of each other according to different principles and independent of the power supply.

Figure 67 shows the component provided with a safety valve in an embodiment adapted to be installed at the connection point of the household machine to the water mains.

The structure of the component according to figure 67 is in agreement with the previously described embodiment according to figure 51 and figure 52 with the difference that the valve zone I has also been provided with a solenoid valve of the afore-mentioned membrane type, 445 and with a suitably formed stream room joining the inlet zone II, said stream room taking care of fluid disturbances transmitted from the valve zone.

Figure 67 shows only the valve seat 446 of the safety valve, diaphragm of the control chamber and other components of the valve as disclosed with reference figure 51 being omitted. The cylindrical inlet 447 of the
component is preferably arranged in parallel with the outlet tube 448 and is provided with a volume flow regulator of the type previously described. As indicated schematically by a dash-line contour 444 the inlet can also be placed in the position described above. The component according to figure 67 and 68 also differs from the earlier embodiments by the fact that the outlet tube 448 of valve zone V forms a straight outlet 449 which is built in together with a hose arrangement 450 connecting the component installed at the water supply connection point with the household machine.

The hose arrangement consists of an inlet hose 451, an outlet hose 452 for discharged washing or cleansing liquid, a light guide or electrical wire for signal transmission, all surrounded by a leakage hose 455. The leakage hose is, preferably, connected to a supervised leakage collecting container placed in association with or within the household machine casing. The outside of the leakage hose can also be provided with a cable 454 for conducting pilot signals to existing solenoids operating the valves. The hose arrangement 450 is shown in a radial section in figure 69, where also a pressure hose 456 is included for operating a pressure controlled safety valve in case the valve 445 has been replaced by this type of safety valve, described with reference to figures 70 and 71.

This embodiment also results in a depressurized inlet hose during periods when no quantity measurement takes place. By providing the outlet detail 457 component of the lower wall portion 458 of the housing with a moisture or pressure sensitive sensor 459 and a connection sleeve 460, joined to the mentioned lower wall portion 458 for obtaining of a pressure-tight leakage hose, encircling the inlet and outlet hose, electrical wires and the optical light guides according to figure 69, a complete supervision system is obtained when including sensor $S_{11}$ surveying internal leakage (not shown in figure).

The optical light guide can be jointly used here for sensing ball movement as well as the status (position) of the sensors 459 and $S_{11}$ according to the second aspect of the invention, whereby sensor 459 and/or $S_{11}$ can trigger closing of the safety valve of the valve zone by optical or optical/electrical signal transmission according to previous description at external and internal leakage.

Figure 70 shows a second embodiment of the component provided with a safety valve. The pressure controlled safety valve 465 is located in the second main chamber, i.e. in valve zone I in sub-chamber 466, downstream
the cylindrical inlet 467, which entirely agrees with the cylindrical inlet described in connection with the embodiment according to figure 51. Furthermore, the sub-chamber 466 is joined to the housing 468 on the upstream side of the housing which also agrees completely with the housing 352 of the design according to figure 51. The sub-chamber is divided, in the manner described earlier, by diaphragm 469 whereby the control or pressure equalization chamber includes a disk 470 which is fixed in an upper position by the action of a permanent magnet 471 acting through wall 472, whereby said wall is making the control chamber 473 leak-tight. The permanent magnet 471 is enclosed in a ventilated pressure chamber 474 with connection 475 for control pressure. Preferably, the chamber 474 is concentrically connected to control chamber 477. Furthermore, in chamber 474 there is an elastic membrane 478 fitted in, which is movable axially and to which the permanent magnet 471 is fixed. Thus the disk 470 (or the plunge) consisting of magnetic material will be kept in the shown position as long as the membrane 478 assumes a normal position corresponding to a normal pressure in chamber 477. If the pressure is increasing in the chamber 477, connected to the household machine, because of the household machine being overfilled, the membrane with its permanent magnet 471, will be axially displaced upwards and disconnect detail 470, which under the influence of gravity or a spring force (the spring not shown) will be displaced downwards and block the drainhole 479, which opens towards the channel connected to the inlet zone II. This results in the safety valve being closed in a way previous explained. A modified embodiment of the pressure controlled safety valve is shown in figure 71. The drain hole 480 of the valve membrane can be blocked by means of a freely movable ball 481. The ball is normally displaced to an unstable position 482 on a higher level but is locked against movement caused by tilting effects, vibrations etc. by a groove or a permanent magnet. Furthermore, the ball is placed in immediate proximity of a pressure chamber 483 provided with a membrane, carrying the permanent magnet 484 and/or close to a movable, mechanical arm 485. Should the pressure increase in the control chamber 489 as a result of overfilling in the household machine, or should is the arm 485 be displaced for the same reason by means of a float mechanism the ball will leave its unstable position. By gravity the ball will roll to the room, preferably cup-formed, which has been formed concentrically with the drain off hole in the valve membrane 486.

By blocking the drain hole 480 opening towards the channel connected to
the inlet zone II, the safety valve is closing in accordance with the
foregoing description. By also supplying the valve membrane with a
concentrically located permanent magnet the gravitation and pressure
forces can be amplified by a magnetic force increasing the sealing
pressure in the contact surface excercised by the ball 401 when sealing
the drain hole, said ball being coated with sealing compound and made of
magnetic material. Alternatively, the ball can be moved from its unstable
position by means of a membran influenced by the pressure or by the
mechanical device. If so the cavity for the ball is made in the membrane.
The control chamber can also be provided with a mechanism 490, allowing by
a simple manual pushing that the ball be reset to its normal unstable
position, said mechanism being used in connection with the service work
necessary after a overfilling incident. The pressure operated safety valve
according to figures 70 and 71 can also be controlled and released by
means of the strong pressure drop generated in the vortex chamber in
radial direction at increasing tangential velocity $v_t$. If the pressure
conduits are connected in different radial positions along a radius of the
vortex chamber, and if the pressure chambers 483 or 474 is provided with a
suitable, adjustable spring loaded mechanism as 488, figure 71, the safety
valve can be adjusted to be released by the radial pressure drop at a
predetermined tangential velocity $v_t$, i.e. at predetermined maximum
permitted flow rate. It is also possible to modify the design of the
pressure controlled safety valve by allowing the membrane to be operated
by means of an axial play also by a mechanical shut-off function operating
the membran separately or in coordinated action. The component with its
safety valve is here installed in connection with the leak-free bottom of
the household machine, and a float placed in the leakage water room is
affecting by a mechanical mechanism such as levers (i.e. displacing) said
deformable membrane 478. By the mechanical play mechanical as well as
pressure controlled release of the safety valve can take place. The lever
mechanism may also displace axially a plunge, replacing above-mentioned
membrane, and in this way seal off the drain hole which results in closing
of the safety valve.

By way of example the invention has been described with reference to the
application sector of household machines. However, the component has
several field of applications, such as heating and sanitary technique,
technique for liquid distribution, for example watering systems or systems
for economic water utilization in premises and accommodations.
Figure 72 shows a practical embodiment of the component adapted for adjustment of the flow rate with simultaneous volume measurement of the regulated fluid flow, an operation which, for example, is necessary for optimum adjustment of the energy flow in a heating element. Thus, the component can also be supplemented with a conventional device for temperature measurement integrated in the housing, preferably located in the outlet tube (not shown in figure).

Figure 72 shows the component in an axial section symmetrically through the housing 495 and suitably designed for the above mentioned use. The housing 495 comprises a first and a third main chamber, including an inlet zone II, a sensing zone III and an outlet zone IV and a valve zone V, respectively, as previously described with reference to the embodiment according to figure 51. The housing 495 is provided with an inlet 496 connected to the inlet zone II and an outlet 498 connected to the outlet tube 497 of the valve zone V. The practical design of the inlet and the outlet is in agreement with practice prevailing in the sector of application.

The outlet tube 497 of the valve zone V projects into the first main chamber of the housing, and the top or the upper wall portion 499 of the housing contains a chamber 500, constituting the outlet zone IV, located axially directed and concentric with the outlet tube. A valve 502 provided with a handle 501 and located concentrically with the outlet tube is fitted leak-tightly into the upper wall portion 499 of the chamber. The body of revolution of the valve 502 with seal arrangement can in known manner, by a threaded sleeve in the end wall portion 504, be manually adjusted for regulation of the flow by cooperation with a valve seat 505 formed in the end section 506 of the outlet tube.

The fluid entering through the inlet will under proper measuring circumstances pass the housing, while propelling the sensing element, here shown in form of a ball 507, around the outlet tube, in a path concentrical with the outlet, making measurement of volume possible in a manner previously described, favourable symmetrical inflow conditions occurring around the body of revolution and the outlet tube, with the result that the flow in zone III is undisturbed.

In order to obtain aligned inlet and outlet the design of the housing can be modified in various ways, in doing which the first main chamber can be given suitable inclination angle.

The design of the valve 502 is not limited to that shown in the figure but can be varied in a number of ways known in the art.
The component can also be utilized to attain advanced heating, water and sanitation installations at in this connection occuring filling operations. Thereby it is usually required, besides control of the filling volume also that the water temperature can be regulated. In this case it will be normal to introduce into the housing of the valve component a temperature control device, for example a conventional thermostatically controlled valve.

Apparatus according to the invention are not restricted to the embodiments disclosed but can be varied within the scope of the idea, which form the basis of the invention according to the third aspect thereof.
Claims

1. A method for control of a process for processing goods by at least one liquid, characterized in that
   -- at least one parameter describing the amount of liquid bonded to the goods is sensed during an initial liquid-influenced analysis phase
   -- a state of wetting, at least substantially stationary, of the goods at at least one predetermined condition is identified with the guidance of said sensed parameter value (values) and
   -- said parameter value (values) sensed at said predetermined condition and possibly by guidance of said parameter value (values) established value (values) of the quantity of liquid causing said at least substantially stationary state of wetting, amount of goods, volume of goods, composition of goods and/or structure of goods are used for controlling the process.

2. A method according to claim 1 at a washing process in a washing machine provided with a rotatable laundry container or a agitator unit or with a pulsator unit machinery characterized in that
   -- the process goods, made up of wash goods is substantially homogeneously wetted during controlled liquid supply
   -- the wetting procedure is interrupted when such a amount of liquid is supplied, which empirically is equal to or exceeds that amount which corresponds to a stationary condition of wetting, at said at least one predetermined condition of the wash goods
   -- the laundry container or agitator unit is rotated at a predetermined number of revolution in order to attain said predetermined condition of the wash goods

3. A method according to claim 2 characterized in that the laundry container or agitator unit is rotated at an increasing speed of rotation within a predetermined interval, the substantially stationary condition of wetting being established within the interval.

4. A method according to claim 3 characterized in that the speed of rotation is increased stepwise and that the substantially stationary condition of wetting is established for each step.
5 A method according to claim 2 characterized in that the laundry container or agitator unit is rotated with a decreasing speed of rotation within a predetermined interval at which liquid is supplied and, the substantially stationary condition of wetting being established within the interval.

6 A method according to claim 5 characterized in that the speed of rotation is decreased stepwise and, that the substantially stationary condition of wetting is established for each step.

7 A method according to claim 1 for a cleansing process in a dishwasher, which contains a processing space, characterized in that
   -- the process goods, which is made up of washing-up goods is poured during at a controlled liquid supply
   -- the quantity of liquid supplied to the processing space is compared with the amount of return liquid flowing from said space in order to establish that an at least substantially stationary condition of wetting has arisen, by a substantially stationary liquid film formed along the surface of the washing-up goods.

8 A method according to claim 7 characterized in that the washing-up goods is poured by a separate liquid distribution system arrangement, which is separated from the processing liquid distribution system.

9 A method according to claim 8 characterized in that the liquid pouring takes place in the form of a finely dispersed liquid having a comparatively low kinetic energy.

10 An apparatus for controlling a process for processing goods with at least one liquid, characterized in that the apparatus has means for sensing a parameter describing the amount of liquid which is bonded to the process goods during an initial liquid-influenced analysis phase, means for establishing an at least substantially stationary state of wetting at at least one predetermined condition of the process goods, and means for controlling the process by utilizing the parameter value (values) sensed at said predetermined condition.

11 An apparatus according to claim 10 incorporated in a laundry washing machine provided with a rotatable laundry container or agitator unit or
with a pulsator machinery unit characterized by means for wetting the process goods substantially homogeneously, the goods being in the form of wash goods during a controlled liquid supply, and means for measuring directly or indirectly the amount of liquid which is bonded to the process goods.

12 An apparatus according to claim 10 incorporated in a dishwasher having a processing space, characterized by means for controlled pouring of the process goods, which is made up of washing-up goods and means for comparison the amount of liquid supplied to the processing space with the amount of return liquid flowing from the processing space.

13 A flow throttling-measuring device for fluids, comprising a sensing zone intended for measuring of a flow parameter of the fluid, with an inlet zone and an outlet zone and at least a first throttling element upstream said inlet zone and/or at least a second throttling element downstream said outlet zone, characterized in that
   -- the sensing zone and throttling element (elements) are integratedly included in a housing
   -- the inlet zone is connected to the sensing zone so that a vortex movement is created
   -- the outlet zone extends substantially axially from the sensing zone and
   -- the inlet zone as well as the outlet zone constitute a flow equalizing chamber, adapted to ensure a regular flow in the sensing zone.

14 A flow throttling-measuring device according to claim 13, characterized in that (the first) flow equalizing chamber constituting the inlet zone consist of at least one channel exhibiting a first bend or curve in a first direction.

15 A flow throttling-measuring device according to claim 14, characterized in that the inlet zone extends along a relatively short first segment connected while forming said first bend to the upstream end of a second segment, which constitutes along its length a second bend, in doing which the first bend shows an abrupt angular alteration and the second bend an elongated, rounded form which at least partly surrounds the sensing zone.
16 A flow throttling-measuring device according to claim 15, characterized in that the inlet zone has vanes in its area connecting to the sensing zone.

17 A flow throttling-measuring device according to any of claims 17-16, characterized in that (the second) flow equalizing chamber constituting the outlet zone has less radial extension than the sensing zone and is axially displaced in relation to the sensing zone.

18 A throttling-measuring device according to claim 17, characterized in that the outlet zone has an outer surface, forming a surface of revolution with a radius increasing in the downstream direction.

19 A flow throttling-measuring device according to claim 17 or 18, characterized by a central symmetrical body of revolution which at least in part passes through the outlet zone.

20 A flow throttling-measuring device according to claim 17 - 19, characterized in that the outflow opening of the outlet zone is located centrally of said zone.

21 A flow throttling-measuring device according to claim 20, characterized in that said outflow opening is located within the symmetrical body of revolution whose free end constitutes a valve seat for said second throttling element.

22 A flow throttling-measuring device according to any of claims 19-21, characterized in that the symmetrical body of revolution has a radial extension increasing in the downstream direction.

23 A flow throttling-measuring device according to any of the claims 17, 18 or 22, characterized in that that the flow opening from the outlet zone to the second throttling element is located peripherally in the outlet zone.

24 A flow throttling-measuring device according to any of claims 17, 18 and 22, characterized in that that the outlet zone are provide with several peripherally located outflow openings to several throttling elements located downstreams.
25 A flow throttling-measuring device according to any of claims 13-24
characterized by at least one flow throttling element comprises direct
acting and/or pilot operated valve.

26 A flow throttling-measuring device according to any of claims 13-25
characterized in that the sensing zone is included in a first main chamber
having a rotatable indicator body, means being provided for detecting the
passage of said body in a gap in an optical transmission link, and the
main chamber being tilted such that the indicator body is deblocking said
gap in a resting position.

27 A flow throttling-measuring device according to any claims 13-26
characterized in that at least one flow throttling element is comprises of
an adjustable safety valve controlled by the flow rate.

28 A flow throttling-measuring device according to any claims 13-27
characterized by that at least one flow throttling element comprises a
pressure-controlled valve.

29 A flow throttling-measuring device according to claim 28, characterized
in that the valve is a safety valve with a central drain hole in the
membrane received separating, the flow passage from a control chamber, a
control body located in the control chamber being arranged to assume a
position sealing or freeing the drain hole in dependence of a fluid
pressure.

30 A flow throttling-measuring device according to any of claims 13-26,
characterized in that at least one flow throttling device element
comprises electrically controlled safety valve.

31 A flow throttling-measuring device according to any of claims 13-30,
characterized in that the symmetrical surface of revolution, externally or
the symmetrical body of revolution is designed as an gaze detecting
sensor, for example, by way of a float or by light diffraction.

32 A flow throttling-measuring device according to any claims 13-31,
characterized in that at least one of said means for flow throttling
comprises a partial chamber formed as a vortex chamber for gaze detection.
33 A flow throttling-measuring device according to any of claims 13-22, characterized by a first main chamber comprising inlet, sensing and outlet zones, a second main chamber located upstream said main chamber and a third main chamber located downstreams, the second main chamber including a flow regulating unit and the third main chamber a direct acting valve or a pilot operated valve.

34 A flow throttling-measuring device according to any of claims 13-33, characterized in that the outlet zone has two or more outflows connected to the same number of chambers in a group constituting the third main chamber, each chamber including a valve acting as a flow control valve.

35 A flow throttling-measuring device according to any of claims 13-34, characterized by a second sensing zone, whose inlet zone constitutes a by-pass channel to the first sensing zone, and whose outlet zone connects to the outlet zone of the first sensing zone.

36. An apparatus for controlling and/or monitoring fluid components or fluid systems by means of at least two sensors, characterized in that the sensors are connected in series in an optical link and comprise at least two optical sensors, or at least one sensor and at least one optical transducer, for determining volume, flow rate or mass handled by a fluid system or a component, at least one transducer signal or one optical sensor signal being subordinated to the signals of the remaining sensors and transducer by said latter signals showing optical dominance when all signals are optically combined in a light guide common to the signals, such as a fiber optic light conducting cable, the optical link further comprising optical detecting means, inactivated transducer or transducers granting the light an uninterrupted path in the optical link and signals in the optical link being arranged to be generated by sensor-controlled modulation and/or total or partial blocking or deblocking of said optical link when at least one sensor is externally activated, activation being caused by a physical state, such as pressure, temperature, concentration, moisture level, being changed, and the optical detecting means being arranged to detect the sensor-controlled change of the parameter value or values of the signal, such as light intensity amplitude, light wavelength, signal frequency, signal pulse width etc., and to emit signals to a circuit for signal processing and generating at least one controlling and/or monitoring signal.
37 An apparatus according to claim 36, characterized in that the cable of
or the light guide of the optical link is composed of one or several
fibers constituting one or several channels for one or several optic
signals.

38 An apparatus according to claim 36 and 37, characterized in that the
sensor or sensors of the optical link or light guide are accommodated in a
housing to which the optical fiber or fibers of the optical link or light
guide are connected, the sensor or sensors blocking or deblocking the
light transmission of the fiber link or light guide completely or in part
by a mutual lateral displacement of fiber end surfaces formed by the fiber
or fibers being divided substantially, perpendicular to the fiber axis,
said end surfaces occupying a centered position at maximum light
transmission, or by lateral displacement or radial displacement of an
element totally or partially blocking, filtering or unblocking the light
transmission said element being movable in the gap of the divided fiber,
said divided fiber or fibers or said element being joined with a probing
body located in the sensor housing, said body at least in part being made
of a material combination of materials, such as bimetal, memory metal, a
moisture sensitive and dimensionally changing substance etc. or formed as
a float or a pressure sensitive membrane sensing external physical
variables, as temperature, pressure, moisture, liquid level etc.

39 An apparatus according to claim 37, characterized in that the sensor or
sensors of fiber link or light guide is accommodated in a housing, to
which the optical fiber or fibers the optical link or light guide are
connected, the sensor or sensors blocking or deblocking the light
transmission of the fiber link or light guide totally or partially by the
light path direction being changed, or by the light intensity being
attenuated when the light is transmitted through or reflected against one
or several in the light path of the sensor located curved or plane
boundary surfaces between the solid material of the sensor housing and the
sensor-detected fluid accomodated in the sensor housing, the material of
the sensor housing and said fluid having different refractive index,
creating an altered sensor signal when an enclosed detected fluid is
exchanged, as from gas to liquid or to liquid to gas.

40 An apparatus according to claim 37, characterized in that the sensor of
sensors of the optical link or light guide are accommodated in a housing
to which the optical fiber or fibers of the optical link or light guide is
connected, the sensor or
sensors changing or deblocking the light transmission of the fiber link or
light guide, partially by a fixed or movable optical filter or reflecting
surface inserted in the light path, sensitive to pressure, temperature or
moisture, altering the light transmission or reflection conditions
in co-variation with the pressure, temperature and moisture of the sensed
fluid, the light wavelength or light intensity changed by the sensor,
being detected by the receiving means for generating at least one control
and/or monitoring signal.

41 An apparatus according to claim 37, characterized in that the sensor or
sensors are made up of an undivided fiber or fibers changing the light
transmission of the fiber link in co-variation with operating temperature,
operating pressure or bending radius of the fiber.

42 An apparatus according to claim 36 or 37, characterized in at least one
first optical sensor which senses pressure or liquid level in the fluid
system or the fluid component and operates at discrete, optical signal
levels, and/or one transducer measuring volume, volume flow or mass
handled by the system or the component and at least one second optical
sensor operating continuously in the fluid system or fluid component and
measuring, in a light gap inserted into the optical link, a change of the
intensity of light transmitted or reflected in the light gap, said change
co-varying with the state of the process fluid, such as its contamination
and temperature.

43 An apparatus according to claim 42, characterized in that said second,
continuously (analogous) operating sensor is formed of a light emitting
sensor surface connected to the fiber link and formed of the evenly
distributed end surfaces of the fibers, and of a light receiving surface
substantially parallel with said light emitting surface and connected to
the fiber link and formed of the evenly distributed end surfaces of the
fibers, said light receiving sensing surface, constituting the optical
sensing surface, a light gap being formed between said surfaces which gap
can also be common with said first sensor, the second sensor distributing
substantially evenly the light, which is transmitted in the fiber or
fibers and incidencing from the light emitting sensor surface, over the
optical sensing surface of the the light gap, causing an attenuation of
the light
intensity because of light absorption, dispersion etc. in stationary or
flowing fluid occurring between the emitting sensor surface and the sensing
surface, in relation to the conditions of the fluid, such as its contents
of solid particles, light absorbing substances etc., said dynamic changing
of the light intensity being arranged to be detected by detecting means.

44 An apparatus according to claim 43 in fluid processing or fluid
affecting process goods as cleansing goods, wash goods, fluid displacement
bodies etc. contained in at least one process goods container and/or in at
least one surrounding process liquid container with or without a leakage
collecting container situated on a lower level and separated from the
process liquid container, characterized in that at least one transducer
associated to the said system or to the fluid conduit system of said
component or to a member supplied by the conduits of the system or
component such as the process goods container and/or at least one fiber
optic sensor $S_2$, associated to said process container goods or process
liquid container or measuring volumes, and channels, or pump and hose
systems, are connected to at least one fiber optic sensor, which overrules
said sensor(s) and transducer(s) and is associated to the lower leakage
collecting container and/or to the process liquid container.

45 An apparatus according to claim 44 characterized in that leakage liquid
within or without the leakage collecting container is arranged, at
malfunction, of said systems or said components, to be conducted by
multi-wall in- and outlet hoses to the overruling sensor or sensors,
which are connected at least to the lower leakage collecting container, or
to inlet or outlet hoses or to external liquid supply components, said
multi-wall hoses forming open, pressure-free or closed pressurized
channels communicating with the overruling sensor or sensors.

46 An apparatus according to claim 44 and 45 characterized in that the
process goods container and the process liquid container of the fluid
system consist of the laundry container rotatable about a vertical or
horizontal axis, and of the fixed installed washing liquid container in a
laundry washing machine, respectively, the leakage container being shaped
as an open, trough-formed leakage tank constituting a leak-free bottom in
the laundry washing machine casing.
47 An apparatus according to claims 44 or 45 at a dishwasher characterized in that the leakage container is shaped as an open, trough-formed leakage tank constituting a leak-free bottom in the dishwasher casing.

48 A method for optical controlling and/or monitoring fluid components and fluid systems characterized in that
--- light is continuously or periodically emitted
  by optical light emitting means in an optical link, comprising a light guide, such as a fiber optic cable, at least two series-connected optical sensors or at least one optical sensor, and at least one optical transducer for determining volume, flow rate or mass handled by the fluid system and an optical detecting means
--- a physical state, such as pressure, temperature, concentration, moisture or level, is sensed by means of the respective optical sensor
--- signals are generated in the optical link by sensor-controlled modulation and/or total or partial blocking or deblocking of the optical link when said physical states are sensed;
--- at least one transducer signal or one optical sensor signal being subordinated the signals of the remaining sensors and transducers by said latter signals showing optical dominance when all signals are optically combined in the light guide or the fiber optic cable and
--- the sensor controlled change of the parameter value or values of the signal such as light intensity amplitude, light wavelength, signal pulse width etc., is detected by the optical detecting means and is signal processed by a circuit for generating of at least one controlling and/or monitoring signal

49 A method according to claim 48, wherein the optical link comprises at least two optical sensors, characterized in that at least a first sensor assumes, at external activation by a first physical state, such as liquid level, liquid pressure etc., one of two discrete optical signal levels at an altered physical state, corresponding to the threshold value of the sensor of sensors whereas at least a second sensor assumes at external activation by change of a second physical state such as light transmission, light reflection etc., an optical signal continuously varying with the second physical state, the optical threshold value which corresponds to inactive respectively active sensor status of said first sensor or sensors, then exceeds and/or is below the dynamic optical operating range of the said second sensor or sensors.
high R.P.M.      Fig 6b

low R.P.M.      Fig 6a
# INTERNATIONAL SEARCH REPORT

**International Application No.** PCT/SE 91/00758

## I. CLASSIFICATION OF SUBJECT MATTER

> According to International Patent Classification (IPC) or to both National Classification and IPC

| IPC5          | A 47 L, D 06 F, G 01 F, N, G 05 B, D |

Documentation Search other than Minimum Documentation to the extent that such Documents are included in Fields Searched

SE, DK, FI, NO classes as above

## II. FIELDS SEARCHED

- **Classification System**
- **Classification Symbols**

## III. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>EP, A1, 0159202 (ESSWEIN S.A.) 23 October 1985, see claims 1,5</td>
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*Special categories of cited documents:*

- **A** = document defining the general state of the art which is not considered to be of particular relevance
- **E** = earlier document but published on or after the international filing date
- **L** = document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- **O** = document referring to an oral disclosure, use, exhibition or other means
- **P** = document published prior to the international filing date but later than the priority date claimed
- **T** = later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- **X** = document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
- **Y** = document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- **E** = document member of the same patent family

## IV. CERTIFICATION

- **Date of the Actual Completion of the International Search:** 29th April 1992
- **Date of Mailing of this International Search Report:** 1992-04-30

**International Searching Authority:**

**Signature of Authorized Officer:**

**Harriet Ekdahl**

SWEDISH PATENT OFFICE
### III. DOCUMENTS CONSIDERED TO BE RELEVANT

(Continued from the Second Sheet)

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### III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

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V. □ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. □ Claim numbers............., because they relate to subject matter not required to be searched by this Authority, namely:

2. □ Claim numbers............., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. □ Claim numbers............., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 8.4(a).

VI. □ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

This International Searching Authority found multiple inventions in this international application as follows:

1) Method and device for control of a process for treating goods with liquid, in claims 1-12, 2) device for control of fluid flow, in claims 13-35, and 3) device and method for optical control of fluidic components and fluidic systems, in claims 36-49.

1. □ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. □ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. □ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the new claims, it is covered by claim numbers:

4. □ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest
□ The additional search fees were accompanied by applicant's protest.
□ No protest accompanied the payment of additional search fees.
ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. PCT/SE 91/00758

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