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ODEN CORPORATION
Advanced Technology Liquid Filling, Dosing, and Blending Systems

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MASS/BLEND®
GENERATION 3

THE ODEN
CONTINUOUS STREAM
DIGITAL BLENDING SYSTEM

THE PROVEN SOLUTION

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ODEN'S

GENERATION 3

MASS/BLEND®

CONTINUOUS STREAM DIGITAL BLENDING SYSTEMS

INTRODUCTION

Over the past decade, the state-of-the-art in liquid products manufacturing has shifted dramatically away from large batching systems. The preferred method for liquid products preparation is now continuous stream blending.

The appeal and merit of continuous stream blending systems, as distinct from older batching systems, is clear. Some of the advantages include:

- **Elimination of large volume holding tanks.**
- **Elimination of large volume batch transfer times.**
- **Much smaller overall process system volumes.**
- **Greater product compounding flexibility.**
- **Much faster product species changeover.**
- **Increased ability to do small volume, short run liquid products.**
- **Substantially lowered capital asset cost commitments on a volume for volume basis over batch systems.**

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- **Far more electronic control and automation of the product formulation process.**
- **Statistical process control (SPC) data yield is inherent to the hardware and the control architecture.**
- **Performance is testable and quantifiable in real time.**
- **Multi-layer and multi-method performance verification is possible.**
- **Product consistency and reproducibility are superior to large scale batching.**
- **Product waste and system loss is substantially reduced.**
- **System cleaning (typically clean-in-place) is simplified, standardized, and shortened.**
- **System clean-out effluent volumes drop dramatically.**
- **The "wall" between the liquid products processing department and liquid products packing department is eliminated.**
- **Product preparation and packaging becomes seamless.**
- **Product component waste is reduced.**
- **Product processing floor space commitment is reduced.**
- **A broader range of liquid products can be processed.**
- **Degrees of separation between SKU and consumer are removed.**
- **Manufacturing agility and versatility are enhanced.**
- **Continuous steam blending advantages flow into every division of the liquid products markets, including food processing, cosmetics, personal care, household, paint and pigments, petroleum, chemical, pharmaceutical, biotech, genetech, and general industrial segments.**

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A BRIEF HISTORY OF CONTINUOUS STREAM BLENDING TECHNOLOGY

Early continuous blending systems were devised primarily for carbonated beverage manufacturers. These systems used PID control loops (proportional-integrating-derivative control structure). The choice of a PID control strategy was "main stream" but ill advised.

Many PID based continuous stream designs quickly encountered major problems. Stop-start events were the first challenge. When a stop-start event occurred, bringing the system back on line with balanced (that is to say accurate) flow and blending ratios required a lengthy flow balancing run time with huge losses of incorrectly blended product that could not be used. The problem was so bad in some cases that the use of a surge tank of several hundred gallons capacity was required to allow steady state proportioned flow to continue during brief filler stoppages.

A second major problem frequently encountered with PID control based continuous blending systems occurred when the flow rates of the blending streams were altered up or down to adjust for varying filler demand. PID loop controllers are often used to "tame" or control complex nonlinear multi-variable systems which are inherently difficult to regulate. They deal with interacting multiple dependent and independent variables of multi-stream continuous blend systems in a non-real time, statistical way, and "fight" changing parameters on an historical basis. The result of these inherent limitations is a lag in response to flow rate change commands, a loss of correct proportioning (luring implementation of the change), and transient overshoot of the new flow setpoint. These phenomenon are inherent to PID based control schemes and limit the overall performance and benefits of such systems.

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Based upon this history, it is reasonable to conclude that a continuous flow blending design in which each channel is based upon a PID controlled rotary positive displacement pump/flow meter/flow control valve is not the way to build a high precision continuous stream blending system – at least not to the standards of performance for accuracy, versatility, flexibility, and ease of application being demanded in the marketplace.

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ODEN'S SUCCESSFUL AND PROVEN ARCHITECTURE FOR CONTINUOUS STREAM DIGITAL BLENDING SYSTEMS

AN OVERVIEW

By definition, a continuous stream blending system must make fully mixed liquid product available at its output at a makeup rate equal to takeaway demand. The takeaway demand rate is generally defined by the running speed of the liquid product packaging line being serviced by the continuous stream blending system.

An intermittent motion on-off ("digital") multi-channel liquid product blending system which produces very small flow synchronized and completely blended batches of liquid product at a rate greater than a specified takeaway rate can function as a continuous stream blending system. It is upon this central concept that Oden's proven and successful architecture is based. The great virtue of this system design methodology is that the extremely high blend ratio accuracy (typically 0.15% to 0.25%) of each stream component is achieved on a pre-engineered and highly proven basis which eliminates the sources of error and operating problems found in feedback loop designs. And, perhaps equally important in practical terms, the final blended continuous stream flow can be turned on and off at will with absolutely no penalty in accuracy. The system volume is very small and all finished product can be utilized at the end of a blend run. Finally, the output of the system can be directly and automatically varied to conform to the takeaway requirements, thanks to the on-off digital design. Also, thanks to the digital flow design, no cumulative errors in proportioning are possible.

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At the heart of each digital (on-off) flow channel is Oden's electronically controlled servo driven rotary pump/mass meter dosing technology as embodied by Oden's NET/MASS® fourth generation systems (US Patent No. 5,996,650). These units are combined together and integrated with a PLC and a PC based color touch screen operator interface to form a powerful continuous stream blending system. With this system architecture, each channel manages one of the liquid components to be blended into a finished product. Each channel turns on simultaneously and runs for a pre-defined dose time. Each channel's flow is digitally altered on a self-teach basis until the precise mass ratio dose required is delivered in the defined run time, and each mass flow ratio is checked with each flow cycle.

The time synchronized ratio dose (digital flow) from each liquid component channel is combined with the other channels in a particular and novel way.

In operation, each minor flow or additive flow channel is synchronously dosed into the central laminar flow area of the suction port of the primary flow channel servo-pump (see Fig. 1, attached hereto). Because the ratio flows of every channel in the blending system are time synchronized, the minor or additive flows are correctly ratio combined with the primary liquid component of flow as they enter the suction port of the primary flow servo-pump. This unique and proprietary flow architecture is referred to by Oden as GEN3 design and it confers critical operating advantages.

Most important, because each additive or minor stream flow channel terminates at or near the suction port of the primary flow channel pump, the back pressure acting on the additive flow servo-pump is essentially defined only by its own flow structure and the rheology of the

additive liquid. This is the case because the pressure within the suction port piping of the primary channel pump is inherently low (typically at or near atmosphere) and varies little as a function of flow through the primary servo-pump. The back pressure acting on each additive stream is therefore definable and predictable unto itself. The critical concept here is that, regardless of the back pressure acting on the primary flow channel pump, this pressure is decoupled or divorced such that the discharge pressure acting on the additive pump is not altered or affected.

With constant and defined back pressure, the displacement of each additive stream servo-pump per increment of rotation is highly understood, defined, and stable, allowing high repeatability and stability of each synchronized flow dose ratio.

Said another way, the back pressure on the primary flow channel has no influence on the back pressure of the additive flow pathways, and thus cannot alter the flow rate of the additive fluid flow pathways. Therefore, there is absolutely no cross talk or interaction between the ratio flow streams. This elimination of the interactivity of dose or flow between blending channels plays the most essential role in assuring straightforward control and operation of the Oden GEN3 blending system, free of "glitches" or "quirks".

Another important advantage of the Oden GEN3 blender architecture is that, because the ratio dose from each channel is not influenced by any of the other blender channels, each can be calibrated discreetly and separately. Therefore, the set-up values and volumetric or mass ratio dose defined and empirically tested separately for each channel remain valid in full dynamic system operation with all channels flowing synchronously.

The GEN3 MASS/BLEND® architecture also allows direct system performance measurement and validation. Because the discharge pressure of each flow channel is defined only by its structure and the fluid flow rate and rheology, direct ratio sampling of each flow channel in the system is possible and practical as a means of empirical verification and validation of correct blend ratio performance. In practice, each flow channel is provided with a second automatic fast-acting positive shut-off dosing valve identical to the unit used in the combining stream. The second automatic dosing valve in each stream can be selected to allow direct ratio dose collection for volumetric or weight measurement. The collected fraction reflects dynamic operation since the back pressure at delivery is essentially the same as that in the fully operating system.

Another operating advantage of the GEN3 MASS/BLEND® flow architecture is that the additive flow fractions pass first through the primary flow stream pump. As a result, the primary flow pump serves as a pre-mix device, contributing significantly to thorough streams mixing.

Another valuable attribute of the GEN3 design is found in component service life. Because the GEN3 architecture allows comparatively low pressure system operation of the minor streams dosing channels, dosing pump service life is greatly extended. When low pressure operation is coupled with the low pump RPM design used by Oden (typically 500 RPM maximum), useful pump life can be greatly extended, often by an order of magnitude.

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Standardization of flow components is also an attribute of this blending system. In the GEN3 design, each flow stream is operated in an on-off or digital format. Each stream dose is produced by a highly proven three or four element module that has been pre-engineered. For volumetric blending operation, each stream dose is produced by a servo drive, a precision rotary positive displacement (PD) pump, and a designed to purpose fast-acting positive shut-off dose valve. For mass ratio operation, a fourth element is added, a Coriolis mass flow meter.

Just how proven is Oden's Generation 3 continuous stream MASS/BLEND® technology? Consider these facts:

- **Since 1980, thousands of the core technology flow channels (the volumetric Oden PRO/FILL® series) have been successfully installed. These designs are in their fourth generation of development and define the state-of-the-art.**

- **Since 1996, the company has successfully installed hundreds of net weight Oden NET/MASS® mass meter based units (US Patent No. 5,996,650). Oden pioneered this technology and is the acknowledged leader within its industry.**

- **Oden has successfully installed multi-channel continuous steam digital blending systems (MASS/BLEND®) in cosmetic, personal care, paint and pigments, and oral care applications, ranging from pilot to high volume production flows. Oden believes that no company has more continuous stream blending systems in operation today.**

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ODEN'S GENERATION 3 MASS/BLEND® SYSTEM

Consider Fig. 1.0 for a diagram of a basic Generation3 MASS/BLEND® system.

In operation, the various minor stream liquid components comprising a product formula are servo-pump dosed through mass meters and precision dose valves into the suction line or suction port of a primary flow channel servo pump. The primary flow channel consists of the largest ratio liquid component and typically constitutes most of the finished product by mass or volume. Each minor stream dose is flow synchronized to the other minor component streams and also to the primary flow channel stream, so flows of all streams start simultaneously and end simultaneously. With this flow layout, the correct dose fraction of each liquid component is guaranteed to enter the suction or infeed port of the primary flow channel servo-pump with each blender system cycle. The primary flow channel pump produces a flow dose set to 100% of the combined streams mass dose as called for by the product formula. Thus, all of the product constituent streams enter the primary flow channel pump in correct ratio and are pumped out at exactly the same rate and ratios. Thus, flow through the entire system is synchronous.

The use of suction side injection of the minor streams at the in-flow port of the primary stream pump plays a critical role in assuring straightforward operation of the blender system, free of "glitches" or "quirks". This is because suction side injection guarantees that the back pressure imposed on each dose stream by the streams combining structure is very low and, above all, nearly invariant.

Because the back pressure acting on each dose stream at the combining or blending point – the suction port of the main stream pump – is low and rock solid (by design), the auto tune electronic control system quickly achieves the correct stream dose in the correct time (flow synchronization) and easily holds synchronization from blending system cycle to cycle with only small rational trim corrections required.

Looked at from the viewpoint of each minor stream dose channel, the GEN3 use of a low or constant pressure combining chamber consisting of the suction feed to the primary stream pump assures that the back pressure on each minor dose stream is defined by the system components used in that channel and not by any other blending system element. Thus, there is essentially no interaction affecting the ratio dose from one channel by any other channel.

Because the dose from each channel is not influenced by the others in the system, each channel can be calibrated discretely and separately. Therefore, the setup values and mass dose remain valid in full dynamic system operation with all channels operating.

The use of suction side streams combining essentially decouples and separates the crucial mass ratio dosing function from the equally crucial streams mixing function. Both functions must be effectively achieved in a successful continuous stream blending system. With Oden's unique MASS/BLEND® continuous stream blending system architecture, the often conflicting engineering requirements of precision synchronized dosing and complete and thorough mixing of the product can be separately accommodated without compromise because the sizing of the primary stream pump to accommodate the back pressures associated with mixing has no bearing on the engineering requirements of the minor streams components.

With Oden's unique Generation 3 MASS/BLEND® system, the high back pressures typically encountered in the use of static and ribbon mixers are readily accommodated by the use of a suitably sized primary stream pump and servo drive without any concern for the effect this could have on the minor streams. With the Oden design there is no back pressure interaction between blending stream dosing and blending stream mixing.

Oden refers to its Generation 3 MASS/BLEND® as "N + 1 design" where N represents the number of minor dose stream servo pumps required and the "plus one" represents the servo controlled primary stream pump.

In operation, the combined flow rates produced by the system are greater than a planned maximum takeaway rate. Typically, the combined maximum flow rate is established to be about 30% faster in unit time than the maximum takeaway rate.

The elevated infeed flow rates of each formula component allows short (typically five seconds) synchronized runs of each mass meter feed channel, followed by a no-flow time of about one second. This arrangement allows the system to keep up with takeaway demand while operating in the digital on-off format. During the off period, each channel's mass delivery and synchronization are checked and adjusted as necessary. A last in - first out (LIFO) averaging method is used. Each channel is electronically set to dose its correct mass dose in the defined run time by adjusting the flow rate of the servo-pump. The dose constitutes the precisely correct mass ratio required by the product formula. With this method, long term and cumulative ratio errors are not possible, and system performance is assured.

As each stream component is dosed and then blended by the primary stream pump and mixer element, it is displaced into a small finished product tank which typically then feeds a liquid filler on a continuous stream demand basis. A one second "cycle time" is imposed at the end of each aliquot batch, after which another digital batch can be produced if demanded by the filler. Electronic level controls in the small final blend tank provide for fully automatic startup to charge the fluid flow pathway. These level controls also automatically control the overall flow pattern in the system. A "wait" level control allows for sufficient final blend tank capacity to assure completion of any aliquot batch in progress. A "run" level control causes digital batching to begin whenever tank level falls below the run sense point. The wait-run differential is generally tightly set, typically to a few gallons. In practical terms this holds tank level quite tightly about the run sensor level, since this is really the "trip" which initiates digital blending, and when the system is running, product is being made at a rate faster than takeaway. A separate pair of high alarm and low alarm sensors can guard against any possible feed malfunction. In effect, this small final blend tank is little more than a "bulge in the line" and adds very little to the total volume of the system. All of the product entering this tank is finished product and can be packaged. This control scheme, where the filler demand drives sequentially back through blender functions, is referred to by Oden as "ripple back" design.

In the event that a stop command is received by the blending system when the final blend tank is just below the max level and a five second run cycle has just started, the synchronized dose run must be completed to assure that blend accuracy is maintained. Thus, a "surge" capacity equivalent to one digital blending cycle is built into the design. By way of example, in a 200 GPM continuous flow MASS/BLEND® system, one digital blending cycle is no more than

25 gallons in volume, while in a 100 GPM system it does not exceed 12.5 gallons. Thus, with this small buffer or surge volume, the Oden system can be started and stopped and restarted at any time without the possibility of introducing proportioning error because any dose in process can be completed, without compromise, regardless of system status.

Another major advantage of the MASS/BLEND® continuous stream blending architecture is that adequate tank volume provision can be made to insure the availability of sufficient blended product to complete all fills in progress on the filling line, even with a forced shutdown of the feed streams. This assures an orderly packaging line shutdown without the possibility of partial fills. It is also important to note that any product reaching the filler must be, by definition, correctly blended.

In practice, each liquid component flow channel in a MASS/BLEND® system consists of an Oden GEN4 PRO/FILL® high precision servo-pump dosing unit complete with positive shut-off dosing valve and an appropriately sized Coriolis mass meter. Integrated together, these define a NET/MASS® dosing channel. The fact that each channel can be software calibrated on a self-teach and self-correct basis to match flow rates on a non-interacting basis with the other stream dose components means that the major source of system error, flow rate adjustments for changing ratio shifts or changing takeaway rates, is totally eliminated.

This approach also substantially simplifies the software and setup computations required of the system. The broad dynamic range of each flow channel size (up to 100:1) insures that a system design can be successfully utilized across a broad range of product formulas without

the need for extensive re-configurations. Large differences in viscosities and other stream flow characteristics are accommodated from one product formulation to the next.

In summary, the Generation 3 system architecture for Oden's continuous stream digital blending system is extremely simple, logical, easy to program, low in system volume, and completely free of error induced by process variables or system interactions. It can be stopped and started without penalty and all blended product can be utilized. It is a system which is inherently accurate rather than one requiring complex control schemes to "tame". Systems are practical with feed rates ranging from a fraction of a gallon per minute to well over 200 gallons per minute. The GEN3 MASS/BLEND® continuous stream digital blending system is a complete state-of-the-art turnkey solution from a single high integrity supplier, carefully integrated with color touch screen graphics, full recipe capability, and extensive diagnostics.

As a means of illustration, consider the following operating example:

Configure a system to provide a continuous flow of liquid product to a filling line at the maximum rate of 100 GPM.

Note that the math procedures described below are actually performed by the control system, typically a high end PLC combined with a PC based color graphic touch screen operator interface. Also note that this example will utilize mass flow as the streams ratio defining method. It is important to note that the GEN3 architecture can also function accurately and reliably on a volumetric basis using the servo-pumps only, without Coriolis mass flow meters (see Fig. 2.0).

This capability serves as powerful testimony to the inherent accuracy and stability of the GEN3 architecture.

The product volumetric formula is:

	Component	Formula Volume (Gal.)	Component Specific Gravity
1.	Water	56.95	1.00
2.	Flavor A	6.25	0.91
3.	Flavor B	9.20	0.97
4.	Color A	0.88	1.12
5.	Color B	1.05	1.04
6.	Liquid Sweetener	18.75	1.21
7.	Preservative	6.92	.89
	TOTAL	100.0	

Step 1

Convert the volumetric formula to metric units to allow ease of subsequent calculations.

Thus: The volumetric formula, as given, is in gallons. This must be converted to liters. Each gallon contains 3.785 liters. Therefore:

	Component	GPM	LPM
1.	Water	56.95	215.55
2.	Flavor A	6.25	23.656
3.	Flavor B	9.20	34.822
4.	Color A	0.88	3.331
5.	Color B	1.05	3.974
6.	Liquid Sweetener	18.75	70.970
7.	Preservative	6.92	26.192

Note that the flow rate of each formula component is still expressed in volumetric units per minute.

Step 2

Convert the metric-volumetric formula to a metric-mass formula.

To convert the volumetric formula to mass, simply multiply each component volume by its specific gravity. The result is expressed in kilograms per minute of flow (KPM). Thus:

	Component	LPM	Specific Gravity	KPM
1.	Water	215.556	1.00	215.556
2.	Flavor A	23.656	0.91	21.527
3.	Flavor B	34.822	0.97	33.777
4.	Color A	3.331	1.12	3.731
5.	Color B	3.974	1.04	4.133
6.	Liquid Sweetener	70.970	1.21	85.874
7.	Preservative	26.192	0.89	23.311

Note that the flow rate of each formula component is now expressed in mass units per minute.

Step 3

Re-state the mass based formula in terms of required flow rates, adjusted upward to accommodate the digital on-off cycling of the system.

In this example, aliquot dose flow rates will be increased to 30% above takeaway rates. The additional flow factor provides a generous allowance for numerous system function actuation times including a one second cycle time between successive digital cycles. This means that the mass flow rate of each formula component is increased by the necessary increment to insure that the final 100 GPM continuous stream blended flow is available, with the one second off time accounted for. In this example, each mass flow rate is multiplied by 1.30 to effect the necessary increase in flow in unit time. Thus:

	Component	Base KPM	Time Adjusted KPM
1.	Water	215.556	280.223
2.	Flavor A	21.527	27.985
3.	Flavor B	33.777	43.910
4.	Color A	3.731	4.850
5.	Color B	4.133	5.373
6.	Liquid Sweetener	85.874	111.636
7.	Preservative	23.311	30.330

Step 4

Adjust the mass flow rate of each dose channel to deliver the correct aliquot batch mass dose in a 5.0 second run time.

This is done to limit the aliquot dose size. Remember that continuous stream blended flow is achieved by repetitive processing of small subtotal (aliquot) doses. Extensive experiments with mass meters have shown that a minimum "on" or run time is needed to achieve optimal accuracy and repeatability. A five second "on" period is near the minimum run time allowable for best accuracy results. It is crucial to understand that the shortest practical run time self-limits any possible blend ratio error since each channel is analyzed and self-corrected between each flow interval. Thus, the shorter the run time, the more frequent the checks, and the more accurate the results.

The batch component mass flows per minute have been previously derived as kilograms per minute in Step 3. To re-express these flows, in ratio, for a five second flow period requires only that they be divided by twelve. Thus:

	Component	5 Second Mass Flow (Kilos)
1.	Water	23.352
2.	Flavor A	2.332
3.	Flavor B	3.659
4.	Color A	0.404
5.	Color B	0.448
6.	Liquid Sweetener	9.303
7.	Preservative	2.528

The system cycle mass total is 42.026 kilos. This is a single cycle of approximately 11.10 gallons.

Step 5

After the five second mass dose aliquots are defined, each NET/MASS® servo driven pump and Coriolis mass meter unit is electronically trimmed to simultaneously deliver its precise mass dose in exactly five seconds. The procedure is completed on an auto-tune or self-teach basis and is generally described as follows:

1. **Each flow channel servo-pump flow rate can be linearly adjusted in increments of one point in 999 by digital electronic interface between the system computer and the servo drive.**

2. **A highly stable quartz crystal precision millisecond clock (1000 Hz) is provided to the PLC (this cannot be internally generated to suitable accuracy). This clock allows the PLC to define a precise dose channel run time of 5000 milliseconds (five seconds) without error.**

3. **Each mass meter generates a pulse train which is directly linear in frequency to mass flow. Thus, each pulse defines a known increment of mass flow. This frequency is generally at 10,000 Hz at maximum channel flow and is, thus, capable of very high resolution.**

4. **Because each NET/MASS® channel was sized to fit its required flow specifications, it is assured that each servo-pump can be adjusted in mass flow rate to deliver the required mass dose in 500 ms.**

5. **In practice, each servo-pump is set at correct flow and the mass dose is "counted". The actual mass dose is compared to the required mass dose, using the direct sample ratio dose valves. Thus system start-up is at or very near specification without lengthy trial and error test cycles.**

Automatic corrections (increased flow or decreased flow) are then made to the servo-pump flow rate until the correct mass dose is delivered in exactly 5000 ms. The result is a precise mass flow dose ratio on each channel, with all streams precisely flow synchronized together. A direct dose sample capability is provided for each blending system channel to allow easy verification of dose using an independently validated scale, at any time during blender operation.

6. **After the system is placed into operation, the same check of mass flow vs. time is made on every flow stream on every system cycle, thus assuring continuing precision flow rate accuracy and synchronization without the possibility of accumulated error. It is important to understand that this comparison and correction process is to insure time matched flow ratios in order to insure precision ratio blending. Note that the correct mass dose is delivered on every aliquot dose cycle, regardless of channel flow rate.**

7. **Extensive computational checks of the batch formula are made to eliminate any possibility of mathematical error.**

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8. **Each NET/MASS® dose channel is designed with extensive real time diagnostics. Any malfunction can be digitally transmitted to the PC based graphical color touch screen and displayed in full message text.**

9. **Up to three layers or levels of independent and discrete performance verification can be provided. This level of redundancy allows Generation 3 MASS/BLEND® to be used in even the most mission critical blending environments.**

For information on Oden's patented Generation 3 MASS/BLEND® Continuous Stream Digital Blending Systems contact Gary Laidman, Vice President Sales, Oden Corporation, 199 Fire Tower Drive, Tonawanda, NY 14150. Phone: 800-658-3622, Fax: 716-874-1589, www.odencorp.com, e-mail: glaidman@odencorp.com.

Figure 1

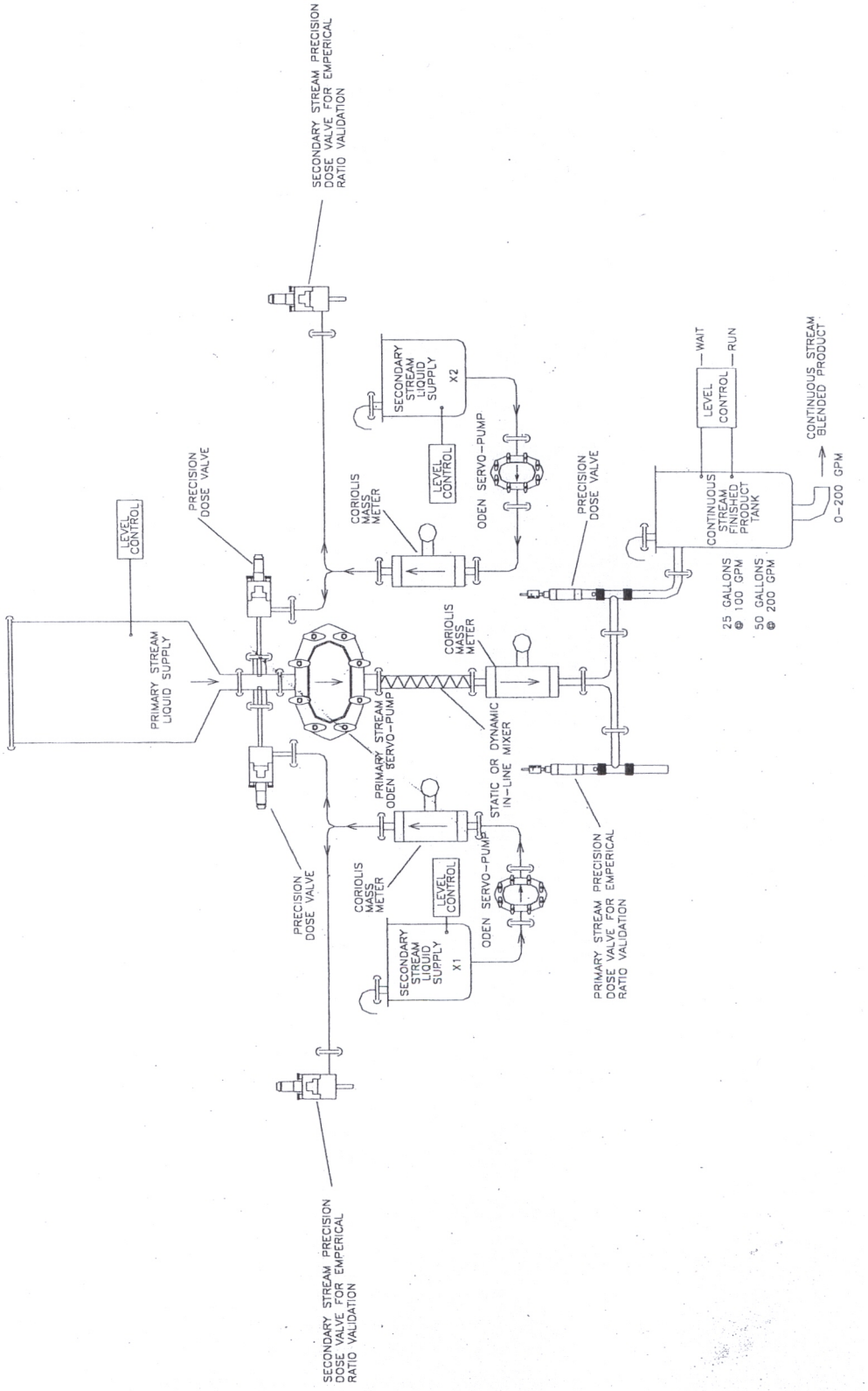

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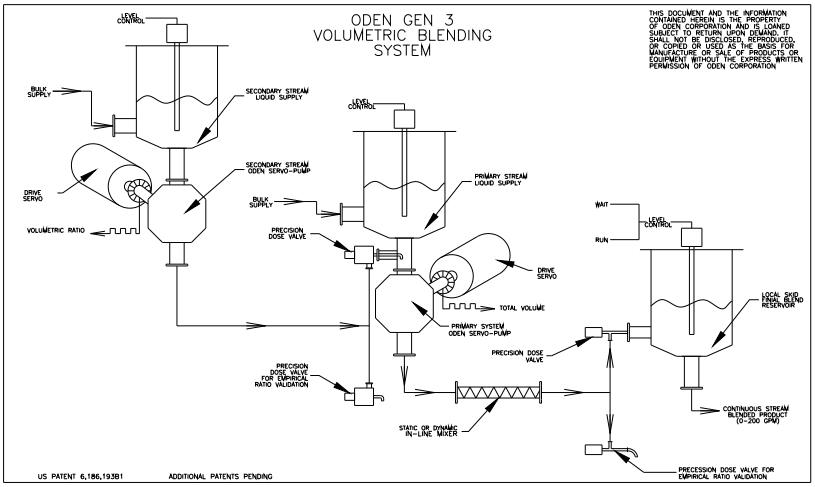
Figure 2


ODEN GEN 3
VOLUMETRIC BLENDING
SYSTEM
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VOLUMETRIC RATIO
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PRIMARY STREAM LIQUID SUPPLY
BULK SUPPLY
PRECISION DOSE VALVE
DRIVE SERVO
TOTAL VOLUME
PRIMARY SYSTEM ODEN SERVO-PUMP
PRECISION DOSE VALVE FOR EMPIRICAL RATIO VALIDATION
STATIC OR DYNAMIC IN-LINE MIXER
WAIT
RUN
LEVEL CONTROL
LOCAL SKID FINAL BLEND RESERVOIR
PRECISION DOSE VALVE
CONTINUOUS STREAM BLENDED PRODUCT (0-200 GPM)
PRECESSION DOSE VALVE FOR EMPIRICAL RATIO VALIDATION
US PATENT 6,186,193B1
ADDITIONAL PATENTS PENDING

Figure 3

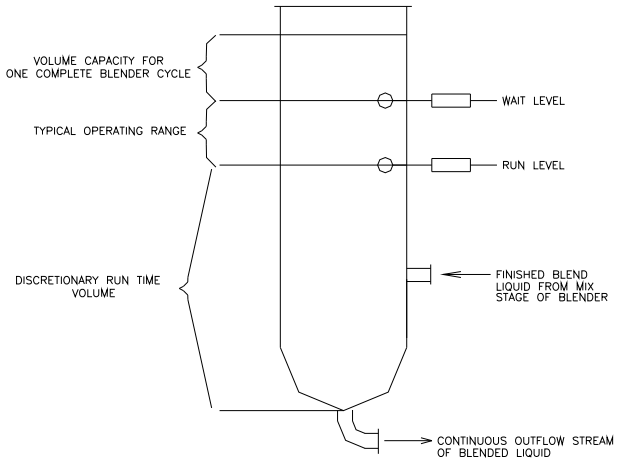

FIgure 4

There are many variations: For example:

•Precision pressurized systems for liquid products using volatile solvents or gases
•Class I, Div I, Group D explosion proof systems
•Dynamic mix systems
•Redundant valved systems
•Digital pressure control (DPC) systems