Littleford

Polyphase® Systems

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Littleford Polyphase Systems are the solution to many of the most rigorous process demands imposed by viscous reaction, viscous drying and solvent recovery applications. The systems are the synergistic combination of process hardware and technology. Whether the application is reacting, drying, heat transfer, or a combination of all, Littleford can provide the equipment and associated technology. And at Littleford, technology represents more than a solution, it represents an optimized solution based on economic, environmental, and process criterion.

Littleford Polyphase Systems

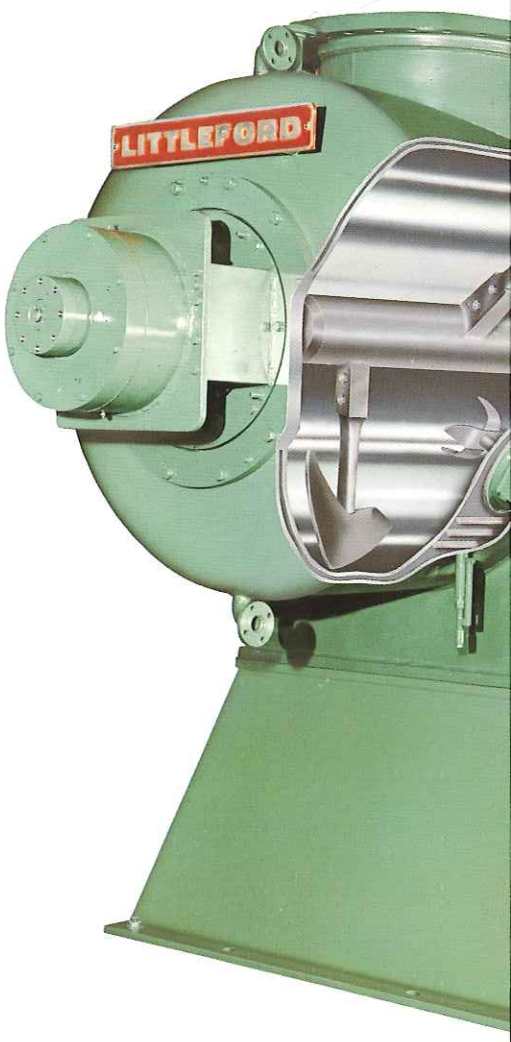
Littleford Polyphase Systems, consisting principally of a processing vessel, combine mixing functionality with specialized pressure vessel design to accommodate product objectives through chemical and/or physical reactions; to affect drying or solid phase concentration by solvent removal; and solvent recovery by reclamation of overhead vapors. It is extensively applied to processes requiring simultaneous, dual functionalities of heat and mass transfer in the chemical, pharmaceutical and food industries.

Polyphase vessels utilize a versatile mixing mechanism designed for processing materials in the granular or powder state, the paste or pseudo plastic state and the transition region between these states. The objective when applying a Littleford Polyphase System to a specific application is to achieve mechanical fluidization of the product mass and affect the advantages associated with mechanical fluidized agitation. However, in many applications, it is necessary to operate efficiently in the paste or pseudo plastic state where mixing is characterized as laminar flow or high shear type. The ability of the Polyphase vessel to efficiently accommodate high shear mixing and transform the mass through the transition region to the fluidized state characterizes the unique mixing functionality available.

Littleford's Polyphase processor achieves solids suspension in the gas phase by mechanically fluidizing the material within the horizontal, cylindrical processing vessel. Mechanical fluidization results from the close-clearance, plow-shaped mixing elements mounted on a concentrically rotating shaft. An optimized axial to radial velocity ratio of the solid particles is achieved by the size, shape, peripheral speed and geometric arrangement of the mixing elements on the shaft. High-speed chopper assemblies are strategically located through

Product Features

- **Vessel connections** in compliance with process requirements, including component addition, cleaning, maintenance, sight glass, sampling and instrument provisions
- **Injection nozzles** for continuous addition of vapors and liquids, typically located in close proximity to chopper mechanisms
- **ASME Code construction**
- **Provision for field or site insulation**
- **Optional construction materials** include specialty alloy internals, clad or solid, and stainless steel heat transfer jacket. Product contact surfaces available of specialty alloy construction to accept corrosive and hazardous chemicals
- **Internal finishes** in compliance with process requirements
- **Wall scrapers** available for appropriate applications



- **Vapor dome** available in various designs to accommodate diverse vapor streams with provisions for particulate or dust removal, mist elimination and accommodations for external heat transfer (reflux condensor)
- **Feed and discharge connections** are of a contoured design to reduce dead zones and crevices to permit smooth operation with minimal product retention during vessel loading and discharge
- **Cryogenic design**
- **Sanitary design** can be provided to meet U.S.D.A. specifications
- **Shaft** can be designed to accommodate flow of a heat transfer medium, primarily to avoid accumulation of material on shaft surfaces
- **Drive options** include multiple or variable speed, mechanical or hydraulic, for various service classifications

the vessel wall to retard agglomeration of particles resulting from physical, chemical or electrical bonding.

Paste or pseudo plastic mixing is achieved by the appropriate mixing element design and vessel configuration to accommodate these high, apparent viscosity materials characterized by minimal mixing resulting from inertial forces developed in the fluid. Mixing is achieved by physically pushing the material from one portion of the vessel to another; by continuous kneading of the material; by extension of the contact area between adjacent portions of the mix fluid; and by division and recombination of portions of the mix.

The Littleford Polyphase vessel is completely jacketed with flow channels to yield efficient heat transfer. Vessel connections are provided in accordance with the requirements of specific applications. Liquids or gases may be added or removed during a particular process. The Polyphase vessel is designed for operation at vacuum and pressure conditions over a wide range of temperatures.

Process Considerations

The Littleford Polyphase System achieves simultaneous, multiple functionalities in one process vessel. This means less material handling and greater efficiency in less plant space, as well as better quality control throughout the process. The following are process operations applicable to the Polyphase vessel:

- **Heat Transfer** — indirect through a heat exchange medium, or direct through continuous or intermittent addition of a liquid or gaseous component.
- **Mass Transfer** — including mixing of one or more components, dispersion of trace ingredients, promotion by physical disturbance of the liquid-solid or gaseous-solid interface, diffusion of liquids or gas into the solid, momentum transfer between solid components, and evaporation or volatilization of a component.
- **Granulation** — achieved by the controlled addition of a binding or cohesive agent to the material within the vessel.
- **Chemical Reaction** — including solid-liquid, solid-gas, solid-solid, and liquid-liquid phase where reaction products are solid.
- **Physical Reaction** — such as in the preparation of emulsions, dispersion, gels, etc.
- **Extraction** — extractions which require chemical or physical modification to release extractable components from substrate and those characterized by low diffusion rates from the substrate.

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Fluidized Bed Mixing Action

The plow-shaped mixing elements create a fluidized bed effect which yields favorable, corollary results to those obtained by conventional pneumatic fluidized bed processes, such as mobility, hydrostatic pressure, uniform temperature and solids composition, and maximum free surface; negligible internal diffusional resistance; and, negligible resistance to diffusion at the external surface.

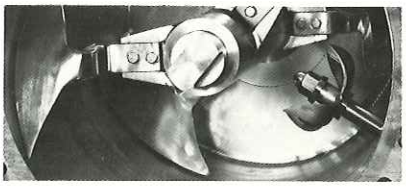
Fluidization also alters the rheological behavior between solid particles by eliminating or reducing bonding between particles. This phenomenon best describes the functionality that is available *only* with the Littleford Polyphase system.

The practical effect of this functionality is a high particle surface-to-volume ratio, excellent momentum transfer and the achievement of good heat and mass transfer. The mechanical action can be precisely controlled through a range of gentle to intense mixing action, as the friability of the particle dictates.

Chopper Assembly

The Polyphase's chopper assembly, including drive, is of unitized construction and flange-mounted to the vessel. Various blade configurations are available depending on the specific process objectives. The most commonly specified type (shown below) is the tulip type with four tips, each in a different plane of traverse.

The choppers compliment the action of the mixing plows by dispersing trace liquid or powder additives, retarding agglomerate formation and speed reactions by promoting surface phenomenon.

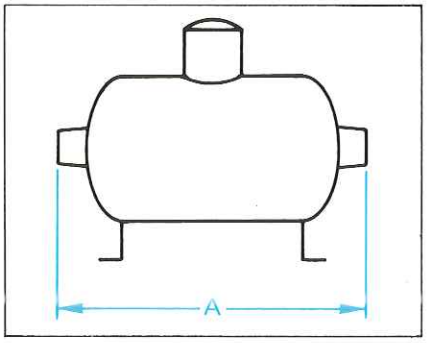


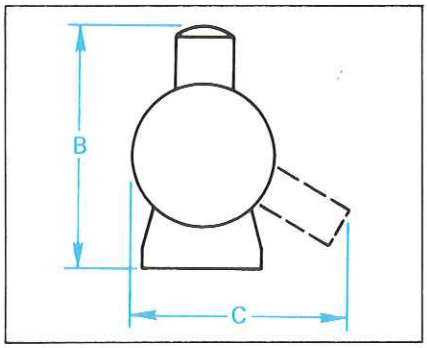
Mechanical Seals

The Littleford Polyphase vessel features a shaft design which will accommodate packing, but is characterized by double mechanical seals on the main shaft and chopper shaft. The double mechanical seals result in the confinement of gases and vapors.

The design of the seals eliminates slots and crevices where product may be deposited, abrasives and other contaminates are thrown from the rotating ring, and, temperature control of the seal components is maintained. A forced circulation seal lubrication and heat transfer system is an intergral part of the Littleford Polyphase vessel design.

Standard Sizes of Series DVT Polyphase Processing Vessel





SERIES DVT VESSEL SIZE	TOTAL CAPACITY* Liters	Gallons	Cu. Feet	APPROX. VESSEL DIMENSIONS A	B	C
DVT 50** Lab Models	50	13	1.7	60″	70″	40″
				1520	1780	1020
DVT 130	130	35	4.6	72″	90″	40″
				1830	2290	1020
DVT 300	300	80	10.6	78″	48″	49″
				2050	1220	1240
DVT 800	800	211	28.3	110″	50″	53″
				2790	1270	1350
DVT 1250	1,250	330	44	120″	59″	60″
				3050	1500	1520
DVT 2000	2,000	528	71	132″	66″	68″
				3350	1680	1730
DVT 3000	3,000	793	106	148″	71″	71″
				3760	1800	1800
DVT 4000	4,000	1,057	141	180″	74″	73″
				4580	1880	1850
DVT 6300	6,300	1,664	226	220″	78″	87″
				5590	1980	2210
DVT 8000	8,000	2,113	283	226″	84″	89″
				5740	2130	2260
DVT 10000	10,000	2,642	353	230″	92″	92″
				5840	2340	2340
DVT 15000	15,000	3,965	530	267″	103″	115″
				6770	2620	2920
DVT 20000	20,000	5,284	706	296″	107″	117″
				7520	2720	2970
DVT 25000	25,000	6,605	883	300″	116″	123″
				7620	2940	3120

*Working capacity depends on the process and is normally between 50 and 70% of the total capacity. **Dimensions shown for DVT 50 include cabinet.
NOTE: All dimensions are nominal. Figures shown in color are millimeters.

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Typical Applications of the Littleford Polyphase Processing Vessel

Applications where the Polyphase unit has proven successful are:

- **Chemical Reactions** — of the solid phase classification including metal stearates; metal alkoxides; pharmaceutical intermediates, pesticide derivatives, dye and pigment intermediates including anthraquinone, di-azo and phthalocyanine; cellulose ethers; dry chlorination of aromatics; chemical modification of polymers; and, chemical encapsulation of pesticides and herbicides.
- **Biopolymer Modification** — cellulose sulfidation for film and fiber production, cellulose ethers, guar, protein, starch and biomass conversion.
- **Drying or Solid Phase Concentration** — reduced pressure or vacuum type, particularly those products exhibiting thermal sensitivity such as freeze drying of foods and pharmaceuticals.
- **Solvent Recovery** — characterized by recovery of chlorinated organics, ketones, aromatics and aliphatics.
- **Extraction of Biopolymers** — including proteins, carrageenan, and natural gums.
- **Sterilization of Foods and Pharmaceuticals** — by chemical and thermal treatment.
- **Physical Reaction** — such as required in the manufacturing of catalyst materials.
- **Food Preparation** — physical reaction to formulate synthetic food products such as cheeses, texturized proteins, etc.

Vacuum Drying

In reduced pressure drying applications, the efficiency of the Littleford Polyphase system can be illustrated by examining the following equation representing the quantity of vapor removed from the solid mass:

$W = k (P_s - P_g) A_s$ where

W — Vapor quantity (lbs. per hr.)

k — coefficient of mass transfer (lbs. per [hr] [ft²] [psia]) (At the vapor-solid boundary)

P_s — Vapor pressure of vaporizing liquid (psia) (At temperature on solid surface)

P_g — Partial pressure of vaporizing liquid (psia) (In the bulk or vapor phase)

A_s — Area of solid surface (ft²)

First examine (A_s) which is a function of the drying systems considered. More appropriately, consider A per pound of absolutely dry solid. The Littleford mixing or fluidizing functionality yields an extremely high solid surface area per pound of absolutely dry solid. The side entering choppers eliminate agglomerates of solid materials if such a phenomena exist. The equipment is designed to achieve the maximum A_s obtainable based on physical characteristics of the product.

The coefficient of mass transfer (k) is a function of the vapor velocity and the physical properties of the product. Sparging a diluent or carrier vapor (inert) not only increases (k) but reduces (P_g) which increases the driving force by increasing the term ($P_s - P_g$). (P_g) is reduced by a carrier vapor based on total pressure within the vessel as a function of the sums of the partial pressures. Another advantage of carrier vapor is direct heat-transfer.

Normally, reduced pressure drying applications are not heat transfer limited because of high log mean temperature differences. However, typically heat transfer coefficients are quite high because of the close-tolerance plows and absolute radial mixing within the Littleford vessel.

Technical Data

Heat transfer coefficients for solids, powders or granules in the Littleford Polyphase vessel are normally between 30 and 60 BTU per (hr)/(sq. ft.)/(F°). Heat transfer depends upon:

- Physical properties of the material
- Geometry and distribution of particle size
- Effect of diluent liquids and vapors
- Vessel size and material of construction
- Speed and configuration of mixing elements
- Ratio of product volume to vessel volume
- Operating pressure
- Physical properties of the vapor phase

These values, as well as the dimensions of the mixing elements are determined for individual applications by actual testing at the Littleford Test Center, or in a trial demonstration in the customer's facility.

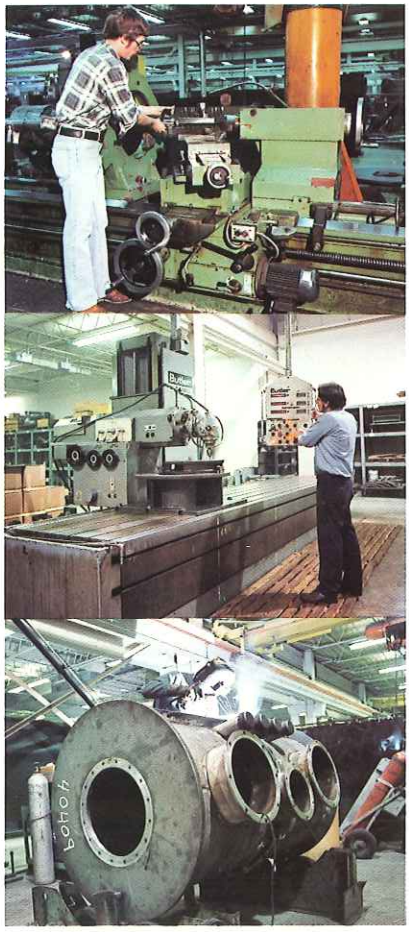
Littleford Manufacturing of Polyphase Processing Vessels

Using advanced production technology, such as laser beam boring guidance and numerically controlled machine tools, Littleford manufactures the Polyphase unit to the close dimensional tolerances needed for uniform and precise multiple phase processes.

Approaching a Century of Service

Littleford Bros., Inc. has produced quality products for industry since 1882. This heritage of engineering excellence, manufacturing skill, and customer service has made Littleford a most trusted name among industrial suppliers.

Littleford looks forward to being able to put its experience, capability, and mixers of exceptional value to work for you. Littleford . . . a name you need to know.



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Littleford Bros. maintains a fully equipped test center for study and evaluation of Series DVT Polyphase vessel applications. Arrange for a qualitative demonstration test conducted by our experienced technicians. Littleford also maintains a fleet of pilot-size reactors for quantitative on-site testing.

Littleford Bros., Inc. can assist you in the development of peripheral technology such as materials handling and conveying, introduction of special high viscosity reactants, handling of vapor streams, dust or particle elimination from vapor streams, instrumentation including computer control, and heat transfer. Your Littleford representative can arrange for you to observe tests on your mixes in our Test Center, or he can arrange for a rental trial demonstration mixer for testing in your own plant.

Littleford Plant and Testing Center located minutes from Greater Cincinnati Airport in Florence, Kentucky

Littleford equipment shown herein is patented and manufactured under exclusive license of Gebruder-Lodige G.M.B.H.

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