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An Improved Vacuum Pneumatic System for Filling Large Dry Chemical Fire Extinguishers

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Mechanics Division

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An improved vacuum pneumatic conveying system has been developed for filling dry chemical fire extinguishers of 150 lb and larger capacity. It features more rapid filling and eliminates the lifting and dumping of cans, with its attendant dust nuisance. The main components are a 1-1/2-horsepower industrial type vacuum cleaner and an especially designed separator cap which fits on the fill-cap threads and serves to separate the powder from the conveying air stream.

Three different separator caps have been designed for three large extinguisher types presently used at military activities. Design variations are necessary in order to achieve the proper balance between powder-transfer rate to the extinguisher and "carryover" of powder to the vacuum cleaner, which varies according to the differing geometries of the extinguisher shells. A powder-transfer rate of 0.40 pound per second was maintained during the fill cycle, and the amount of carryover reclaimed in the vacuum-cleaner bag was 2.0 percent or less.

In using this system, the powder is drawn directly from the shipping cans on the ground, elevated, and placed into the extinguisher with little effort. The lack of dusting during the operation makes it possible to charge these extinguishers indoors.

INTRODUCTION

Dating from the time of their original development, the filling and refilling of large portable fire extinguishers of the dry chemical type, with their finely powdered active chemical agents, has been a wasteful, slow, and disagreeable task. The comparatively crude system of pouring the flow-resisting powder from a 50-lb laboriously hand-supported pail into a funnel, shaped to fit the small filling aperture of the extinguisher, has been the only filling method available. Steady control of flow of the powder with this scheme is almost impossible. Characteristics of fineness and intermittent flowability impart to these agents a proclivity toward overflowing, spilling, and taking flight into the air. The problem is directly proportional to the wind velocities encountered at the time of charging, which must be conducted out of doors to prevent contamination of inside areas. Not only are nearby personnel subjected to the dust nuisance, with its ingestion problems, but also all surrounding equipment and downwind areas become liberally coated with chemically active powder. Frequently, if outside weather conditions are on the damp side, the deleterious exposure of powder to water droplets or high-humidity conditions occurs during the long filling process presently used.

The recent phenomenally successful fire-fighting use of potassium bicarbonate dry chemical (Purple-K-Powder), originated by the U.S. Naval Research Laboratory in 1958, has increased the utility of the large crash-rescue "airlift" extinguisher, containing a charge of 400 lb of this powder. Portable wheeled extinguishers with a 150-lb load of powder are also in wide use at Naval Air Stations. Procurement has been made of several snow-vehicle-mounted dry chemical extinguishers, containing 4000 lb of agent each, for Antarctic use. These units use the new multipurpose phosphate dry chemical for universal fire-fighting purposes. Research is underway to determine the relative effectiveness of 4000-lb containers of dry chemical supplying mechanized turret nozzles for mass application on aircraft-crash fires. Obviously, some improved, mechanized, dust-free procedures for rapidly loading these large fire-extinguishing chemical containers are urgently needed if future maximum utility is to be obtained.

This report contains the results of additional experimentation following the April 1963 publication of the initial work on a device for filling the 400-lb dry chemical airlift extinguisher only (1). For convenience to the reader, many of the earlier test results and the design of the 400-lb filling device are repeated here.

NRL Problem C08-15; BuWeps SEQ 621-008/652-1/F012-05-04. This is a final report on one phase of the problem; work on other phases is continuing. Manuscript submitted February 12, 1964.

OPERATING PRINCIPLE

Quite early in the consideration of solutions to this problem, it was decided that pneumatic conveying offered the simplest, cheapest, and thus the best possibility of transporting this powdered material from its shipping container to an extinguisher shell. There are many industrial processes using this method, whereby finely divided dry materials are suspended in a moving air stream and borne to the desired point. At this point, the air and powdered (or granular) material must be separated, the powder being deposited and the air returned to the atmosphere. Normally, this separating equipment is quite elaborate, usually consisting of a primary "cyclone" separator and one or more secondary bag filters. These devices are necessary in systems operating continuously, and where no allowable discharge of powder to atmosphere is permitted. It was judged that for fire-extinguisher-filling operations, the requirements were not as stringent, and a simpler separating arrangement could be designed for the purpose.

The practicality of a simple extinguisher-filling system for field usage would depend on the degree of separation or powder deposition that could be obtained at or within the powder container with a minimum of special equipment. Also, it was desired to have a minimum degree of powder classification, *i.e.*, a minimum separation of separation of particle sizes in the powder by "carrying over" an excessive amount of fines in the air stream.

SYSTEM DESIGN

Air Mover Employed

The limited distances of travel and necessary lift heights of material in this particular application of pneumatic conveying did not require critical determinations of air and material losses, nor was a high energy requirement involved. The most convenient air mover available was an industrial type vacuum cleaner used by the janitor in cleaning the laboratory building. It was built by the Spencer Turbine Co. and designated as "Commercial Vacuum Cleaner, Catalog P-135." Measurements indicated that it would create a maximum negative pressure of 5.7 in. Hg with no air flow or produce a maximum air flow of 90 cfm with unrestricted inlet conditions. A four-stage turbine blower moves the air, and a cloth bag filter serves as the final air-solids separator. The bag filter is arranged vertically and permits accumulated solids to drop into a bottom collector box when its total weight permits or when the air flow is relaxed.

Initial Separator Design

As mentioned previously, it is essential that a good degree of separation of powder and air take place within the extinguisher, or else the powder will end up in the air-moving device, where the final bag filter would perform the separation. Experimental efforts were devoted to finding a simple device which could be attached to the normal fill opening of an extinguisher and which would perform with the desired efficiency of separation. The unit for the 400-lb dry chemical device, constructed as shown in cross section in Fig. 1, depends strictly on a 90-degree change in direction of air flow and gravity to achieve separation. The incoming mixture of air and powder enters the container in a downward direction. The diameter of the inlet was made as large as the fill opening would permit in order to keep the inlet velocity and turbulence at a minimum. Air withdrawal is made from the highest possible point and at 90 degrees to the incoming stream. Gravity causes the bulk of the chemical to drop immediately to the bottom of the extinguisher, but the finer particles, with their tendency to remain in suspension, tend to be swept through with the air movement. The critical dimensional limitations make it impossible to separate the two ports by any appreciable distance.

Filling Characteristics of the Original 400-lb-Capacity Device

The separator as shown in Fig. 1 was adapted as a cap to fit the threads and opening of the 400-lb-capacity dry chemical airlift fire-fighting unit. Figure 2 shows the operational test arrangement used to evaluate the overall performance of the system. A 12-1/2-ft length of 1-1/2-in. I.D. wire-reinforced plastic vacuum hose connected the separator air outlet to the vacuum-cleaner inlet, and a second piece of similar hose served

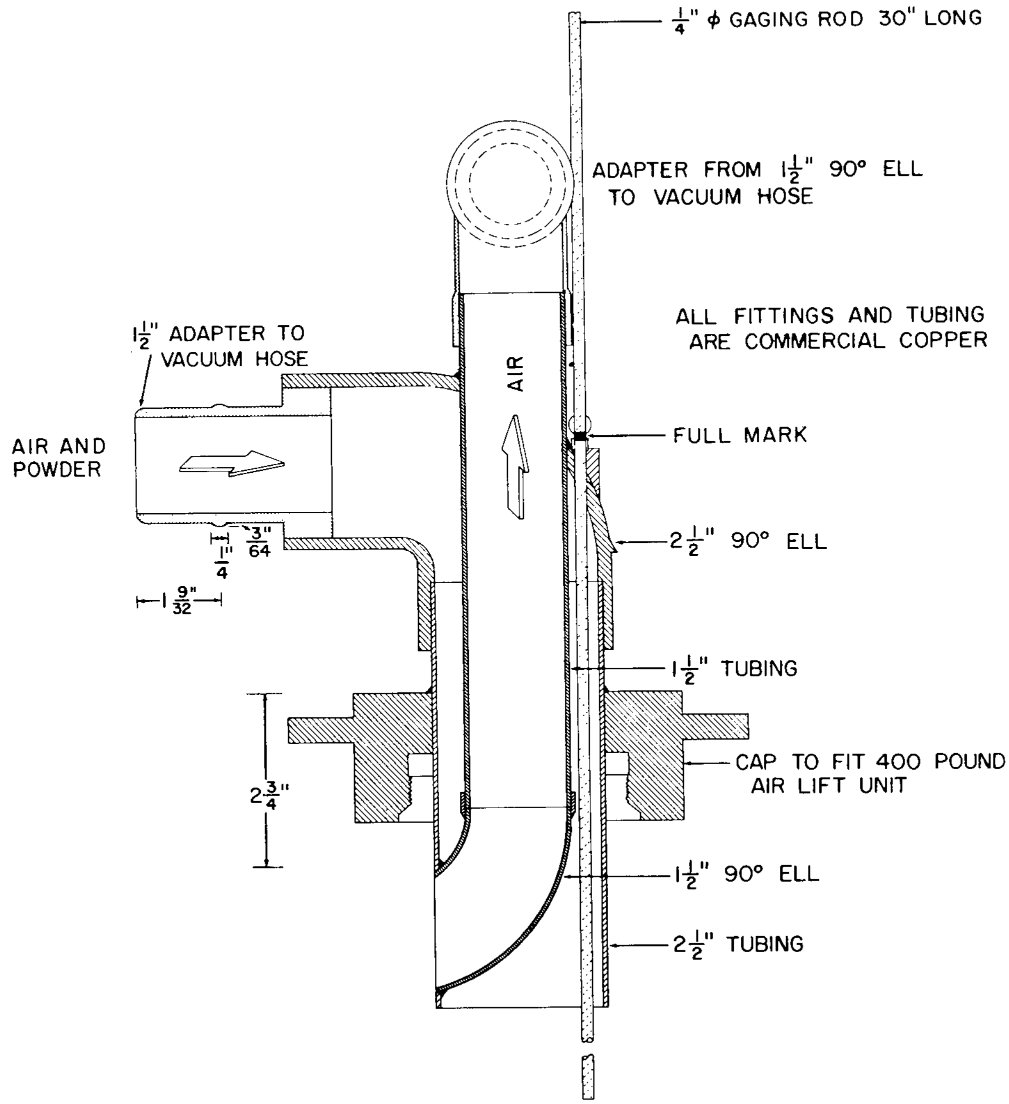

Fig. 1 — Cross-sectional drawing of original separator head for 400-lb dry chemical airlift sphere filling

as a powder pickup line for insertion into the 50-lb dry chemical powder shipping containers. A special fitting (Fig. 3) was used on the intake end of the pickup hose to loosen the powder and to promote better flow and permit a faster material intake. Figure 4 shows a detail of the pickup operation.

Test dry chemical fillings of the 400-lb, 28.75-in.-diameter airlift sphere were conducted to determine the flow rates and other operating characteristics. A manometer was connected to the sphere for measuring the internal pressure during the test runs. The vacuum hose was disconnected from the sphere after emptying each can in order to check the air-flow rate to determine how badly the filter bag on the vacuum cleaner was becoming blocked with powder. The time to empty each 50-lb pail of powder was also measured. At the conclusion of the filling the total amount of powder accumulated in the vacuum-cleaner collector box was weighed. Samples of powder were taken for specific area determinations from the shipping can, the airlift sphere, and the vacuum-cleaner collector box.

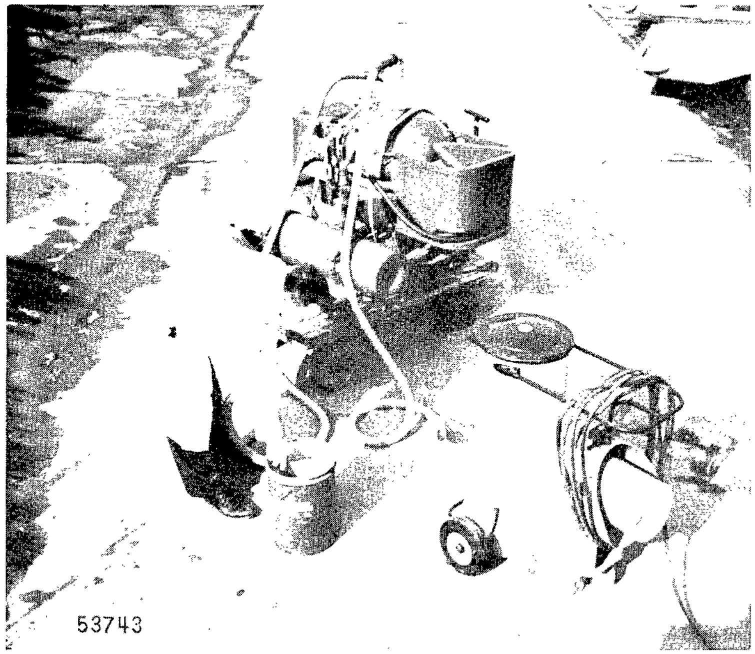

Fig. 2 — Overall view of pneumatic filling system in operation

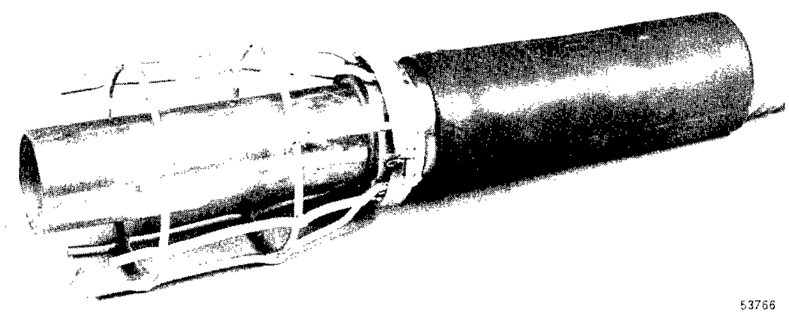

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Fig. 3 — Powder pickup nozzle

There was no progressive fall-off in air flow or vacuum reading within the sphere during the intake of powder. This was taken to indicate no significant powder accumulation on the bag filter surface. An air-flow rate check with a clean filter bag at the start of a run showed a flow of 84 cfm with an unobstructed pickup nozzle. A similar check after picking up one 50-lb pail of powder showed the air flow to have been reduced to 59 cfm by filter blockage. If the blower motor was turned off and the excess powder allowed to drop from the bag wall, the air flow could be increased to 64 cfm on restarting the blower.

It was observed during the actual ingestion and pneumatic transportation of powder that the vacuum reading in the sphere was approximately 5.1 in. Hg. (This was subject to some fluctuation as the operation moved the pickup nozzle in and out of the bulk of powder in the can.) According to the air-flow calibration curve, this corresponds to an air-flow rate of approximately 20 cfm. The actual time of pickup per 50-lb can of powder varied quite widely. These fluctuations appeared to depend more on the operator's technique in maneuvering the pickup nozzle in the can than it did on the air-flow

Fig. 4 — Pickup nozzle removing powder contents from can

volume through the system. This was reflected in the low average rate for the first can of 0.43 lb/sec with a clean bag, but which was 1.14 lb/sec for the fifth can, when the vacuum-cleaner bag should have been in its worst condition of plugging, with powder carried over. The most effective technique seemed to be to keep the nozzle constantly in motion and almost completely submerged to restrict the intake of surface air. Each can was rolled on the floor before opening to loosen the contents and to make it easier for the operator to move the pickup nozzle through the powder.

The amount of material which collected on the filter bag of the vacuum cleaner was weighed after emptying five 50-lb cans. A total of only 8.6 lb had been carried through the extinguisher and into the vacuum cleaner. This was 3.4 percent of the total amount of powder picked up.

In order to determine the degree of powder classification (*i.e.*, powder-size separation) during the pneumatic process, the "before" and "after" powder samples were analyzed by the Blaine technique for specific area. The specific surface of the dry chemical (Purple-K-Powder) in the "as-received" condition was 4650 cm^2/gram; the value for the material charged into the airlift unit was 4,400 cm^2/gram; and the value for the material carried through and collected on the filter bag of the vacuum cleaner was 11,580 cm^2/gram. These values correspond to average particle sizes of 6.0, 6.3, and 2.4 microns, respectively.

Failure of Original Design on 150-lb-Capacity Extinguisher

It was thought that similar advantageous filling results for the 150-lb upright cylinder-type dry chemical extinguisher could be obtained by utilizing the device designed for the 400-lb airlift sphere. Test results failed to bear this out, and other design possibilities were sought for the nonspherical units.

MODIFICATIONS OF ORIGINAL SEPARATOR DESIGN

Centrifugal Separator Design Tests

Centrifugal gas-solid separating devices of the small-diameter or miniature cyclone type are

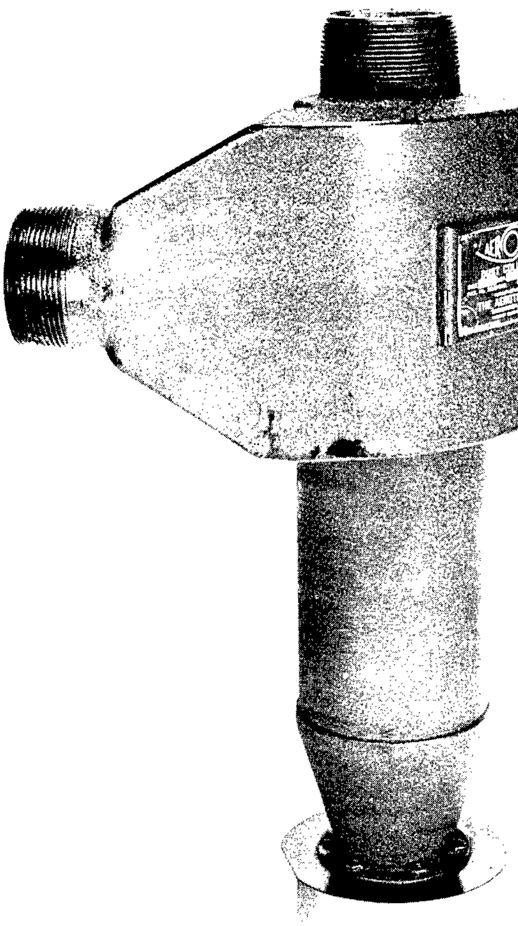

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Fig. 5 – Commercial miniature cyclone separator

well suited for efficient separation of particles in the size range of dry chemical powders from air streams (2). One such commercial tube, manufactured by Aerotec Corp., Greenwich, Connecticut, was obtained and tested (Fig. 5). This type of separator has the advantage of being mounted entirely exterior to the container, thus eliminating the problem of container configurations causing varied interior air-circulation patterns. This location also eliminates interference with the powder level when it approaches the full mark in the container.

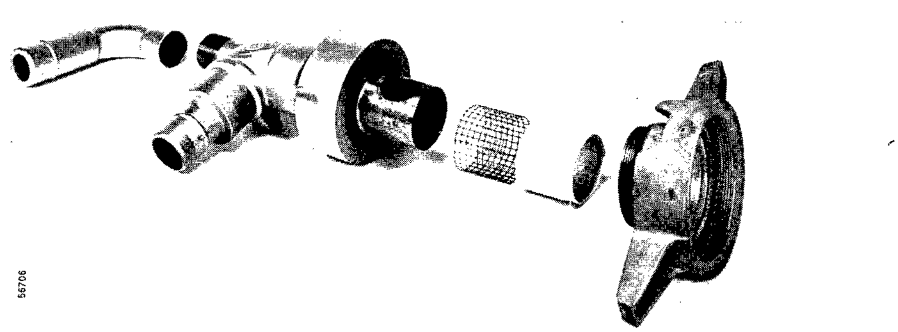
Test runs with this unit on the 150-lb extinguisher while using the usual technique of pickup gave rates of powder transfer between 0.47 and 0.74 lb per sec, while the carryover amount in the filter bag was 5 percent of the total intake. These results showed a considerably lower transfer rate of powder, but the carryover to the vacuum cleaner was less than was obtained with the original separator design on a 150-lb extinguisher. It was felt that the powder loading of the feed stream might have been too high for the particular tube, and additional runs were conducted wherein air was bled into the pick-up line, thereby increasing the air-flow-to-powder-weight ratio. This, however, failed to improve the situation, as the powder-transfer rate not only dropped to 0.13 lb per sec, but the carryover soared to 15 percent. No additional work was done with this unit.

Modifications to Original Separator Design for Other Sizes and Types of Extinguishers

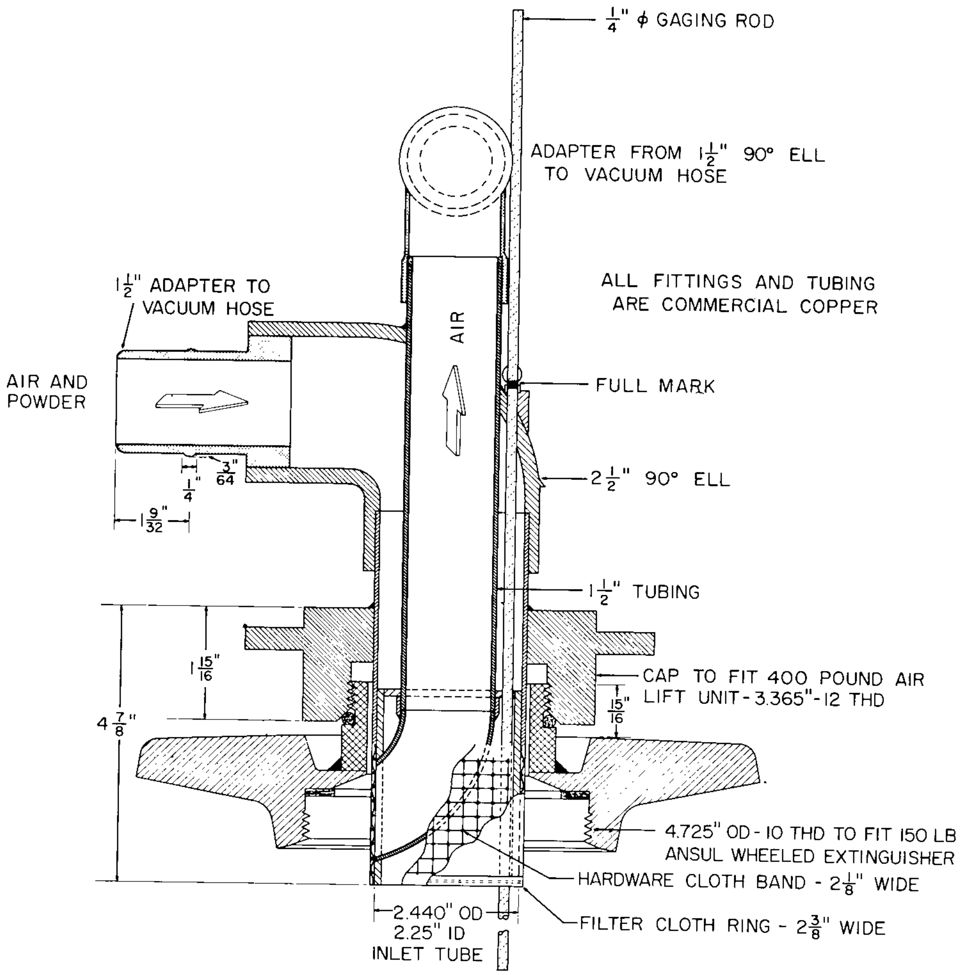
In the interest of standardization, modifications were started on the original 400-lb airlift extinguisher cap design to make it more suitable for filling the 150-lb extinguishers. Various bottom extensions of the dry chemical inlet tube were tried in order to separate the inlet and outlet ports and to reduce the amount of "short-circuiting" of powder to the vacuum cleaner. It was found that appreciable covering of the lower sector of the air-exit hole could be tolerated without reducing the rate of powder transfer, but with a reduction in the amount of carryover. This further suggested that the restriction of a filter cloth over the outlet might not seriously impair the flow of air to the point where the rate of powder pickup was affected.

This modification was tried, and although the carryover was practically zero and the initial powder-transfer rate good, clogging of the filter cloth with powder unduly retarded the powder pickup rate as the run progressed.

By wrapping a piece of 1/4-in.-mesh common hardware cloth completely around the outer tube entering the extinguisher and covering it with a piece of filter cloth, a large filter surface could be obtained in order to minimize clogging. An exploded view of this arrangement is shown in Fig. 6a. The solder nodules on the wire spaced it away from the tube and permitted movement of air behind the filter, all around the circumference to the vacuum-cleaner outlet. This created an effective filtration surface of approximately 18 sq in. The screen and filter cloth were designed to be a slip fit onto the tubing; drawstrings in the top and bottom of the cloth served to seal and secure the assembly.



a. Exploded view of separator head, showing 1/4-in-mesh wire ring, slipover filter cloth, and adapter head



b. Cross-sectional drawing of separator head, showing design dimensions

Fig. 6 – Separator device designed to fit Ansul 150-lb dry chemical extinguisher

The first unit constructed was made to fit a 150-lb wheeled dry chemical extinguisher manufactured by the Ansul Chemical Co. with the construction and dimensions shown in Fig. 6b. A spare aluminum cap from a 150-lb unit was bored out and fitted with a threaded bushing. The top threads of the bushing were identical to the threads of the 400-lb-capacity airlift unit and permitted use of the same separator unit for both extinguishers. When operated in test fillings, it was found that the extinguisher's normal "Purple-K-Powder" dry chemical charge of 125 lb could be filled in 300 sec, for an average powder-transfer rate of 0.42 lb per sec. The amount of powder carried over and reclaimed from the vacuum cleaner bag was only 0.5 percent.

A second separator head was made to fit the 150-lb dry chemical wheeled unit manufactured by Safety First Products Corp. Because of internal threads on the fill connection of this extinguisher and its different shell configuration, some dimensional changes were necessary, as indicated in Fig. 7a and 7b. Filling tests with this extinguisher required 280 sec, or an average rate of 0.45 lb per sec. The carryover to the vacuum cleaner bag was 0.9 percent.

Evaluation of Filter-Cloth Arrangement for 400-lb Device

The improved performance of the new separator design in lowering the carryover through the use of the filter-cloth arrangement made it desirable to evaluate it with the 400-lb airlift dry chemical extinguisher. The inside diameter of the neck on the sphere is slightly smaller than that on the Ansul 150-lb unit, and this necessitated a slight reduction in the internal section of the tube in order to accommodate the screen plus filter. Final dimensions are the same as those given by the drawing in Fig. 8. Thus, a basic separator cap of this construction will fit both a 400-lb airlift unit and a 150-lb Ansul wheeled extinguisher (when a suitable threaded bushing is provided for the 150-lb size) at installations where both units are in use and being recharged.

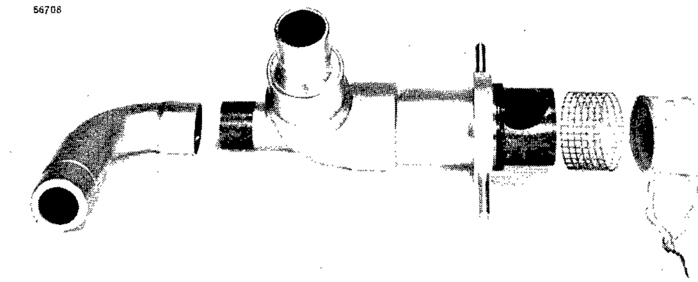
When the separator cap of Fig. 8 was used but without the filter cloth in place, the time required for filling a 400-lb sphere with dry chemical was 1100 sec, or an average powder transfer rate of 0.36 lb per sec. Time checks for emptying of each 50-lb pail of powder showed the pickup rate for the first 50 lb to be 0.67 lb per sec. There was a gradual decrease in rate until with the last pail it was 0.22 lb per sec. The carryover in the vacuum cleaner for the complete filling was 4.0 percent.

After establishing the above base for comparative purposes, the filter cloth-screen assembly was attached and a second filling made. It was immediately evident that the rapid buildup of dry chemical on the filter was interfering with further intake from the pail. In fact, this blockage was so severe and rapid it was not possible to make a complete fill-time determination in this configuration. Further experimentation showed that the only way to prevent this condition was to avoid completely covering the outlet port with the filter. If an open segment approximately 3/8 in. wide was left at the top of the hole, as shown in Fig. 8a, a sufficient amount of air could bypass the filter to maintain a movement of powder. A filling test with this gap required a time of 1122 sec for an average rate of 0.36 lb per sec. This was only very slightly longer than the comparable time without the filter installed; however, the carryover was cut by 50 percent. The pail-to-pail pickup rate in this case did not show the steady, gradual drop of the previous run. On the contrary, the rate for the first can was essentially that of the eighth and last can, and rates for all cans were very close to average rate.

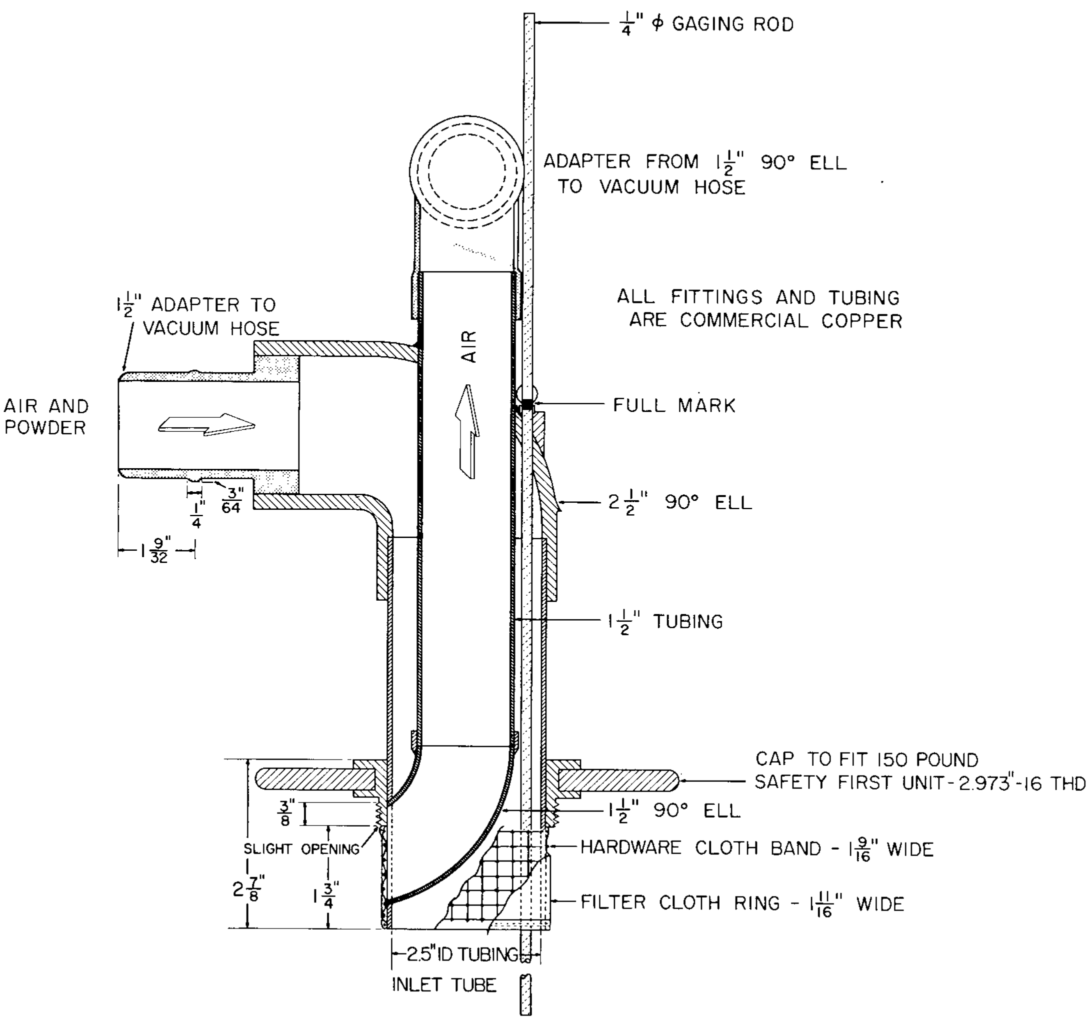
Filter Construction Details

The detailed fabrication of the 1/4-in.-mesh ring with its filter covering was as follows: A piece of 1/4-in.-mesh hardware cloth was rolled, butt-jointed, and soldered to form a cylindrical section of such diameter to make a close slip fit over the inlet tube. The cloth used in making the filter ring was the same as that used in the vacuum-cleaner bag. Top and bottom edges were rolled over and sewn so as to provide for the insertion of drawstrings. The ends were sewn together to form a cylindrical section which would slip easily over the hardware-cloth cylinder. The drawstrings made a seal of the cloth to the screen. The assembly was held on the inlet tube by friction between it and the screen.

The hardware cloth band for the Ansul extinguisher units was 2-1/8-in. wide. The finished filter cloth ring as used when on the 150-lb unit was

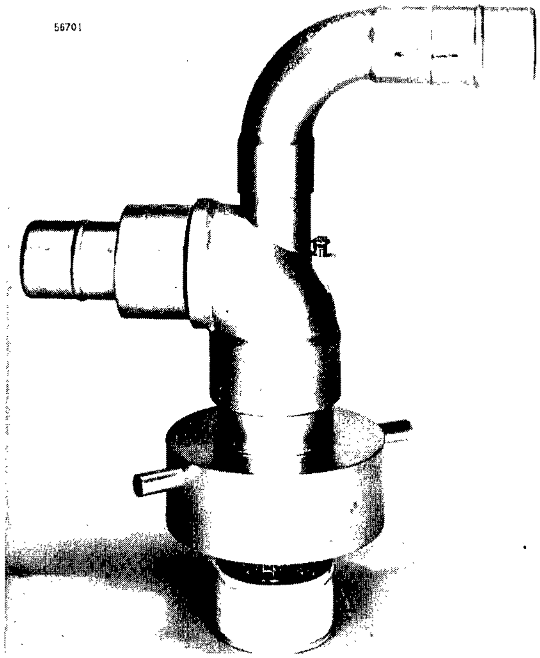


a. Exploded view of separator head

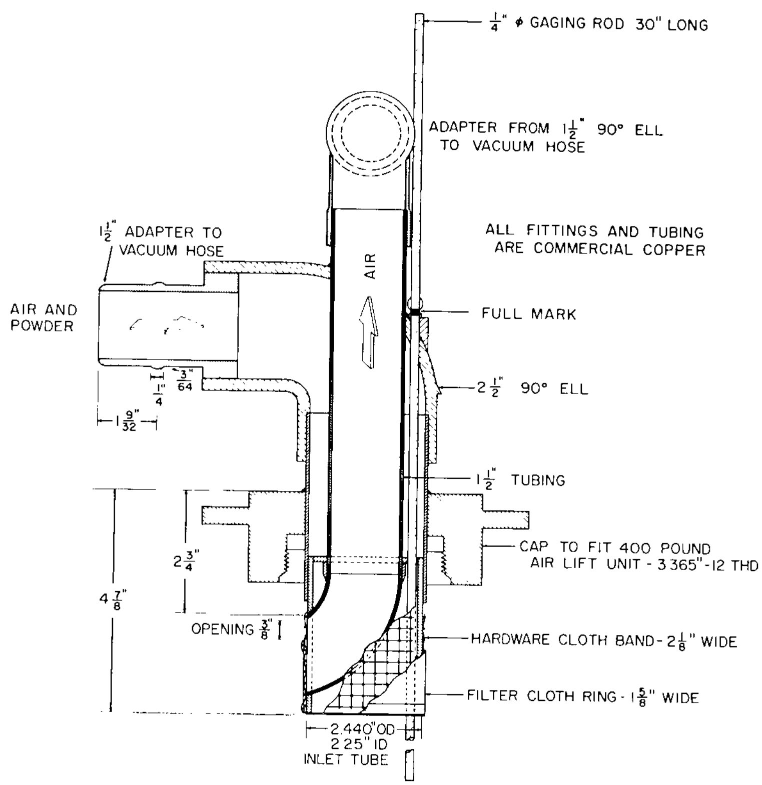


b. Cross-sectional drawing of separator head, showing design dimensions

Fig. 7 — Separator device designed to fit Safety First 150-lb dry chemical extinguisher



a. Separator head; note the air gap above the filter cloth, and the wire mesh



b. Cross-sectional drawing of separator head, showing design dimensions

Fig. 8 – Separator device designed to fit 400-lb airlift extinguisher

2-3/8 in. wide in order to allow filter sealing directly against the inlet tube above and below the screen band. The finished filter-cloth ring as used for filling the 400-lb unit was 1-5/8 in. wide. This permitted the proper 3/8-in. bypass gap at the top, when the drawstring sealed over the screen and against the tube at the bottom.

The different construction of the stored-pressure Safety First extinguisher requires a syphon tube which extends upward almost into the fill neck. In order to insure adequate vertical clearance between the separator fill-cap inlet tube and the syphon tube, the inlet tube was necessarily shorter than that used for Ansul units. Thus, the width of the screen and filter ring were 1-9/16 in. and 1-11/16 in. respectively. A drawstring seal is made to the inlet tube at the bottom and against the screen at the top. Figure 9 shows the cap installed on this extinguisher.

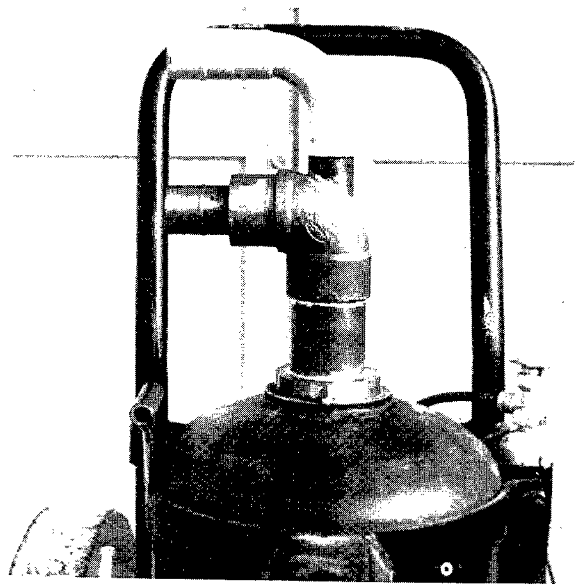


Fig. 9 – View of separator head mounted on 150-lb Safety First dry chemical extinguisher

DISCUSSION

Powder "Conditioning"

In the interest of economy and the large number of runs which had to be made, some of the dry chemical powder used in the tests was recycled. In so doing it was found that powder which had been drawn into the extinguisher and then drawn out was considerably more fluid than that in the shipping pails, even though the latter had been thoroughly rolled before opening. All pickup data reported here were based on the use of new powder to represent normal field recharging operations.

Customary powder-filling procedures require that new pails before opening be turned on their side and rolled back and forth in order to loosen the powder for ease in emptying. This holds true whether the powder is to be sucked out by vacuum or dumped out into a funnel. Work described previously (3) showed that a loosened potassium bicarbonate powder has an apparent density of 0.9 gram/cc. Since potassium bicarbonate has an absolute density of 2.17 grams/cc, this meant that the bulk material contains over 50 percent air, and this is almost sufficient to make it transportable in an air system. It was desirable to allow a limited amount of air into the intake while it was being moved around in the pail. If the intake is completely submerged for too long a time, it may become blocked with a plug of dry chemical. To free this plug it was only necessary to shut off the vacuum-cleaner motor momentarily, permitting the powder to loosen and free itself.

Density of Charged Powder in Units

After seven cans (350 lb) of "Purple-K-Powder" had been charged into the airlift unit (whose capacity has been rated by its manufacturer as slightly less than 400 lb of Purple-K-Powder), the powder level was found to be 11 in. below the top. The apparent density of the material in the extinguisher was calculated to be 1.20 grams/cc, which was considerably higher than the 0.95 gram/cc normally resulting from the old method of filling powder through a funnel. If the filling were completed at the same density until full, it would be possible to charge 499 lb into the unit. The vacuum in the extinguisher evidently removes a portion of the air normally accumulating between the powder crystals, and thus, the higher apparent density is achieved in filling all sizes of extinguishers. Extinguisher discharge tests conducted on vibrated extinguishers (3) indicated powder densities of this order regularly occurred in charged extinguishers but caused no undue difficulties in discharging, provided the unit was of a proper design. All three of the large size extinguishers used in the current study discharged normally after being filled by the described pneumatic process.

The increased density of the powder as charged into the extinguishers by the vacuum pneumatic system insures that there will be no difficulty in getting the full rated amount of charge. On the contrary, a degree of care will have to be exercised in order to prevent overfilling with more than the rated charge when being recharged after a partial usage. The exact amount of discharge, unless it has been complete, is not easily determined, and therefore the method of counting cans put in is not practical. If the extinguisher is overfilled, space is not available for the powder bulk to expand to the density apparently necessary for good flowability and dischargeability. For this reason, the filling head is especially equipped with an access hole, or port (Figs. 1, 6b, 7b, 8a, b) into which a gaging rod may be inserted periodically for depth gaging of the powder contents. A fully charged 400-lb airlift unit will show a powder depth at 14 in. from the gaging port level using the filling conditions described previously.

Air Mover

The particular size vacuum cleaner used in this work appears to be well suited in lift and air-flow capacity for the filling of the 400-lb airlift unit and the 150-lb wheeled unit now used on aircraft fueling sites. The primary air-moving element, being a four-stage turbine, is not prone to damaging wear from the solids passing through it. This, in addition to the fact that the actual running time per year will be low, should insure a long lifetime for the vacuum cleaner. The model vacuum cleaner used in these tests (or a similar cleaner) is carried as a Federal Supply item (FSC Group 79, Class 7910), and this should simplify procurement by local activities. Its estimated cost is $300. Incidentally, these units also have a great utility around firehouses as a piece of cleaning equipment. They can remove floor-cleansing water as well as solid materials.

Dry Chemical Transfer Rate and Carryover to the Vacuum Cleaner

The varying powder-transfer rates and amounts of carryover observed with the equipment used during the program are not clearly understood nor readily explained. The geometry of the receiving container is obviously a factor. The original design of the separator head on the 400-lb unit without the use of a filter ring showed transfer rates from 0.67 to 0.22 lb per sec, with a carryover of 3.4 percent (1). The gradual fall-off in transfer rate resulted from buildup and blocking of the vacuum-cleaner bag. This would seem to indicate a relatively small amount of powder flying around in the container and subject to being swept out; however, when the filter was installed, clogging was almost immediate. By allowing a bypass of air around the filter the severe clogging problem was eliminated, and buildup on the vacuum-cleaner bag was reduced to where the transfer rate, which averaged 0.36 lb per sec, was not slowed during a fill cycle. The filter with an air bypass did not affect the filling time, but did lower the carryover from 3.4 to 2.0 percent.

The high carryover of 16 percent without the filter in the 150-lb extinguisher would seem to indicate a great amount of powder in suspension in the freeboard space. This would have been expected to clog the filter rapidly when installed, but it did not, and the filling runs for the 2-1/2 cans (125 lb) charged maintained the good powder transfer rate of 0.41 lb per sec. The presence of the filter reduced the carryover to about 0.5 percent.

The amount of powder carryover turned out to be a direct function of the degree of filtration provided. The rate of powder transfer was not dependent on the rate of air flow through the system, yet a certain minimum amount was necessary to maintain powder movement.

Significance of Carryover to the Vacuum Cleaner

It is difficult to assess the significance of the 5-percent change in specific surface of the powder resulting from the loss of some of the powder fines into the vacuum cleaner. There is no known fire-extinguishing data on which the degree, if any, of reduced fire-fighting capability could be determined by such small changes; however, it is not believed to cause a resultant detectable change in fire-fighting capability. No further specific surface determinations were made after the implementation of the filter arrangement, and it is not known if this new arrangement would shift the very small carryover to a smaller particle-size range.

The carryover does not necessarily represent a loss of material or specific surface, because the powder taken from the vacuum-cleaner bag can be put back into the powder supply. Only an indeterminable and quite insignificant amount of dry chemical powder was lost by passing completely through the vacuum-cleaner filter-bag cloth. This material, of course, was exceedingly fine and remained in suspension in air as thin wisps of "smoke." If this pneumatic process of filling were to be conducted in an area where even a very small amount of this dust suspension was objectionable, the simple venting of the exhaust of the vacuum cleaner to the outside would completely remove all possibility of dust contamination from the process.

Separator Head Design for Various Units

Because of the varied success of the separator heads in reducing carryover when used in different extinguishers, only those devices described in this report should be taken as acceptable in this respect. Other extinguishers may require adjustments of the separator head in design and dimensions, together with test runs to insure proper operation.

The separator head for the Ansul 400-lb airlift extinguisher should have the dimensions shown in Fig. 8b. Use of the filter cloth for this filling may be considered optional. Its installation will cut down the amount of carryover; however, the amount is still acceptable without it. If the filter is used, the proper top air gap for the cloth filter must be present.

An adapter fitting as shown in Fig. 6b will permit the use of the separator head designed for the 400-lb airlift unit for filling the Ansul 150-lb wheeled extinguisher. In this application the wider filter cloth, covering the entire screen ring, must be used to prevent excessive powder carryover. Note that the top elbow is not made up with solder but is assembled as a slip-fit with grease sealing to make it free-swiveling. This eliminates interference with the handle of the wheeled unit when the cap is being screwed on.

The male threads on the Safety First 150-lb wheeled extinguisher require the dimensions and construction as shown in Fig. 7b. The full filter-cloth ring is also used in filling this unit. As pointed out previously, the Ansul and Safety First separator heads are not interchangeable because of internal interference with the syphon tube.

A similar dry chemical extinguisher filling device and procedure should be developed for the large-capacity multipurpose 4000-lb dry chemical units for Antarctic use now under procurement, and for any large units contemplated in the future. Some increases in turbine size may be necessary for rapid powder transfer in large amounts. Attention might also be directed to the possibility of furnishing 400-lb shipping containers of dry chemical for large-unit filling.

The fabrication of vacuum pneumatic fill-system separator heads for the 400-lb airlift unit and the 150-lb wheeled extinguisher is neither difficult nor expensive. Design specifications for its procurement may be easily finalized, so that existing dry chemical units may be provided with this beneficial modification.

CONCLUSIONS

A simple and effective process for loading large-capacity dry chemical fire-extinguishing units has been developed, utilizing a pneumatic conveying system driven by a 1-1/2-horsepower industrial vacuum cleaner. The system is capable of picking up 0.40 lb/sec of "Purple-K-Powder" dry chemical from its shipping cans and depositing it in an extinguisher shell. All container handling and hoisting, and the dusting nuisance normally associated with the dumping of powder from cans into an open funnel, has been eliminated. The weight of powder lost is not measurable.

The design and construction of the separator heads required to retain the dry chemical in the extinguisher but allow the air to pass on to the vacuum cleaner was a critical factor. Filter cloths and controlled air passages were required in the case of the cylindrically shaped extinguishers.

A reduction of approximately 5 percent in the powder's specific surface value may occur because of separation of some of the powder fines during the pneumatic loading operation. No serious depreciation of powder efficiency is expected from this small change, whether it be returned to the extinguisher or not.

RECOMMENDATIONS

It is recommended that the equipment necessary to apply the pneumatic loading process described here be obtained and suitable instructional procedures issued to enable field application of the system to existing large dry chemical fire-extinguishing units in BuWeps and other activities.

It is further recommended that future procurements of large dry chemical units require provision for a similar pneumatic loading system to facilitate field operations of filling and refilling large extinguisher containers with powder.

REFERENCES

1. Peterson, H.B., Tuve, R.L., Gipe, R.L., and Porter, J.W., "A Vacuum Pneumatic Process for Filling Large Dry Chemical Fire Extinguishers," NRL Report 5942, Apr. 1963
2. Brookman, R.S., Phillippi, J.F., and Maisch, C.L., "Small-diameter Cyclones," *Chem. Eng. Prog.* **59**(11):66 (1963)
3. Peterson, H.B., and Gipe, R.L., "Discharge Characteristics of Potassium Bicarbonate Dry Chemical Fire Fighting Agents from Cartridge and Stored Pressure Extinguishers," NRL Report 5853, Dec. 1962