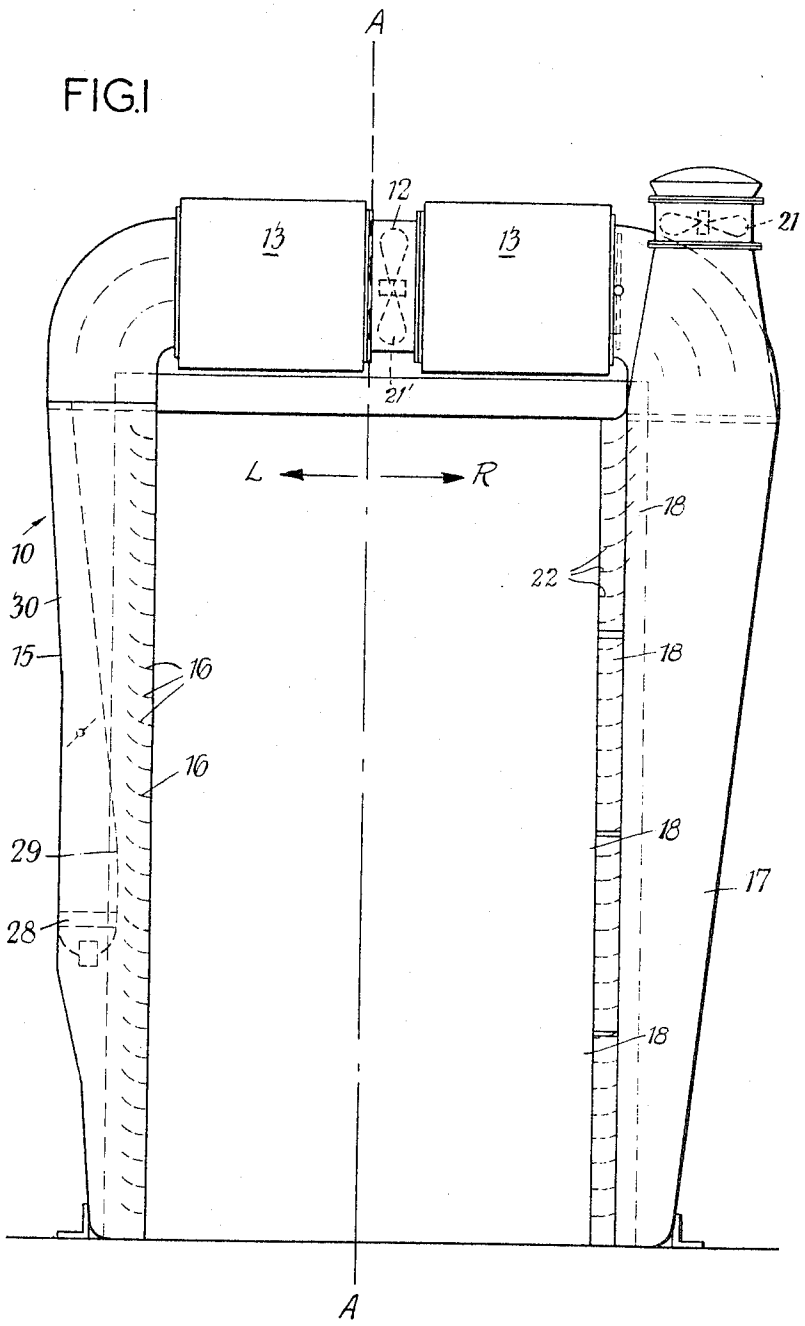
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FIG.1



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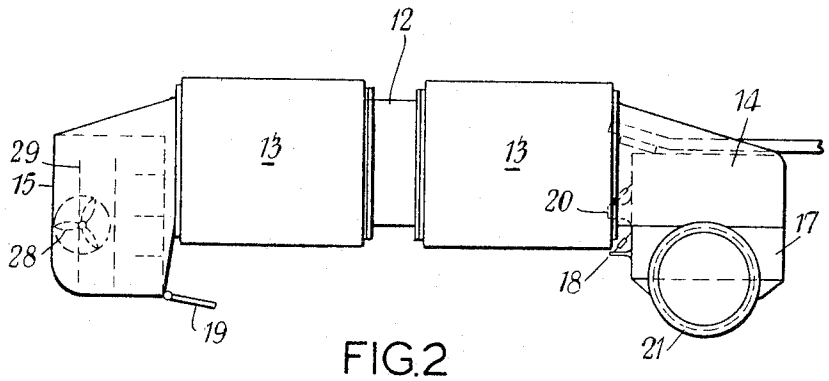


FIG.2

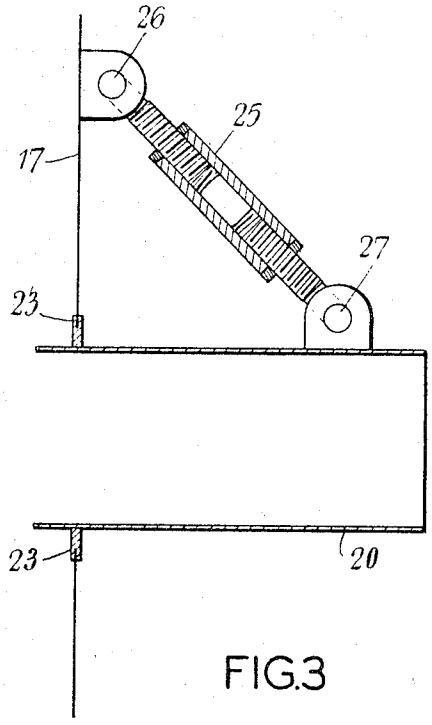


FIG.3

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Fig. 5

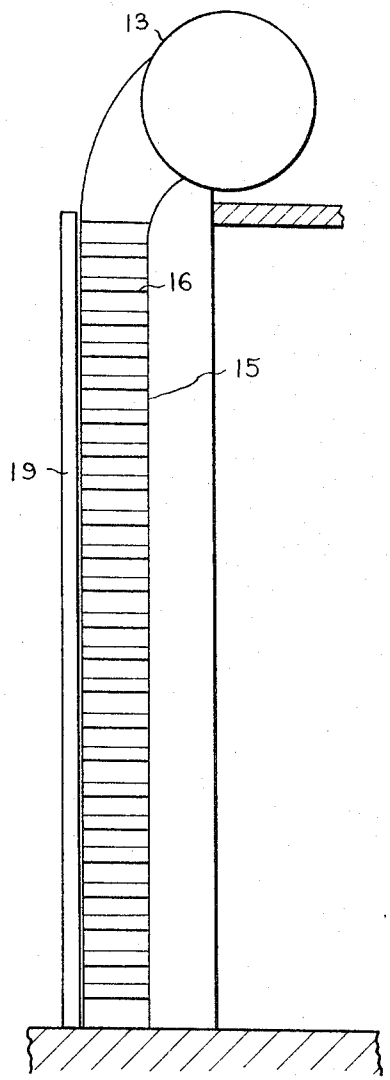
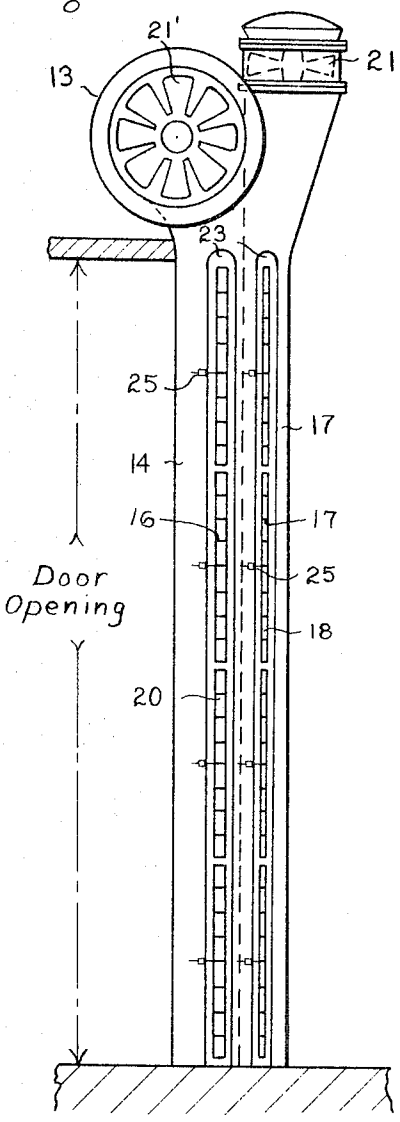


Fig. 4



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AIR CURTAINS

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6 Claims. (Cl. 98—36)

This invention relates to a method and apparatus for establishing an air barrier across a doorway.

A method of maintaining the temperature of a cold store by establishing an air curtain across the doorway thereof has been known for some years. Basically, the apparatus for establishing such a curtain includes a fan unit which draws ambient air into the apparatus and discharges pressurised air across the doorway.

In adapting this known air curtain for the maintenance of temperature within a cold store it is now realised that not only must the temperature within the store be maintained to an appropriate degree but the humidity of the air within the cold store must be such that the cooling system is allowed to continue to function efficienly. If the humidity rises beyond a certain figure, the coils of the cooling system become coated with frost with consequent reduced efficiency.

It is the main object of this invention to provide apparatus for establishing an air barrier across the doorway of a cold store which has the dual purpose of maintaining the temperature and humidity within the cold store.

According to the invention there is provided apparatus for establishing an air barrier across a doorway comprising opposed air discharge and collection means adapted to establish a curtain of recirculated air across the doorway and means on the outside of said recirculation means for establishing a protective air curtain substantially parallel with and of substantially the same direction and overall velocity as the curtain of recirculated air.

The apparatus may comprise first and second substantially parallel elongate air discharge ducts on one side of the doorway and an elongate air collection duct on the opposite side of the doorway opposed to said first discharge duct. Said first discharge duct may be wider than said second discharge duct, and in this case the apparatus is preferably adapted to discharge air from said second discharge duct at higher velocity than from said first discharge duct whereby the recirculated and protective curtains have substantially the same velocity at a position approximately ¾ of the width of the doorway from said discharge ducts.

The discharge ducts are preferably relatively spaced.

The first discharge duct may comprise a plurality of longitudinally aligned nozzle sections individually angularly adjustable about a vertical axis whereby air emerging from said sections may be directed at an angle to the plane of the doorway. Each nozzle section may be mounted in a slot in the associated duct and joined thereto by resilient means forming an air barrier between the duct and the outer periphery of the nozzle at all angular positions of the nozzle relative to the duct. Longitudinally extendable and retractable means may be

pivoted at one end to the duct and at the other end to the nozzle to control angular adjustment of the nozzle.

The air collection duct may have positioned intermediate its ends a booster fan unit adapted to boost suction in the end portion of the collection duct remote from a recirculation passage joining the other end of said collection duct and the first discharge duct. Partition means may be provided extending from the booster fan unit to said other end of the collection duct.

An elongate separation plate may be provided adjacent the side of the collection duct nearer the second discharge duct and adapted to separate recirculated air from the air of the protective curtain. The separation plate may hinged to the collection duct for angular movement about a vertical axis.

According to another feature of the invention there is provided a method of forming an air barrier across a doorway comprising forming a curtain of recirculated air across the doorway and forming a protective air curtain parallel with and on the outside of said recirculated curtain, said protective curtain being of substantially the same direction and overall velocity as said recirculated curtain.

A preferred embodiment of the invention will now be described with reference to the accompanying diagrammatic drawings, in which:

FIGS. 1 and 2 are respectively an elevational view and a plan view of apparatus in accordance with the invention;

FIG. 3 is a detail of FIGS. 1 and 2.

FIG. 4 is a view of the ducting on the right hand side in FIG. 1, showing the disposition of the nozzles, the drawing being a part sectional elevation seen in the direction of arrow "R" in FIG. 1; and

FIG. 5 is a similar part sectional elevation of the duct on the left hand side in FIG. 1, seen in the direction of arrow "L" in FIG. 1.

The apparatus illustrated includes a system of ducting **10**, positioned in a doorway (not shown) of a cold store. That part **12** of the ducting which lies above the doorway includes a fan unit **21'** for pressurising air within a vertically disposed elongated and tapered duct **14** at one side of the doorway, the taper being towards the floor so that recirculating air is discharged substantially horizontally from this duct across the doorway at substantially the same initial velocity over the entire height of the doorway. A somewhat similarly constructed duct **15** is disposed at the other vertical wall of the doorway for collecting the air curtain and the upper ends of these two vertically disposed ducts are joined by the part **12** of the ducting above the doorway, which accommodates a pair of silencers **13**.

Both the vertically disposed ducts **14** and **15** are provided with a plurality of vanes or baffles **16** and **22** respectively which direct the pressurised air horizontally through an outlet slot **20**, or receive the air curtain and direct it vertically upwards for recirculation. These vanes or baffles may be pivotally mounted for adjustment.

Attached to the vertically disposed duct **14** from which pressurised air is ejected to establish the recirculated air curtain is a further vertically disposed and tapered duct **17** with its own fan unit **21** at the top. This further duct **17** is positioned on the side of the duct **14** remote from the doorway and has an outlet slot **18** likewise, provided

with associated vanes or baffles **22** which may be adjustable, to direct an additional air flow across the doorway to protect the recirculating air curtain from ambient conditions. This further air curtain is not recirculated but merely flows away from the doorway past the collecting duct **15** of the recirculating air system **14, 15.**

It is desirable that as little mixing as possible takes place between the recirculating air curtain provided by ducts **14** and **15** and the protective air curtain provided by duct **17** because the recirculated air will consist primarily of dehumidified air from the cold store whereas the outer curtain produced by duct **17** will consist of ambient air which may be humid. To achieve this, the two air curtains are substantially parallel and of the same direction, and the velocities of the air curtains are kept as nearly equal as possible, thus minimising the vortices and eddy currents which would otherwise be set up tending to mix the two.

The apparatus illustrated in the drawings is suitable for situation in the doorway of a cold store. Assuming ambient temperatures to be in the region of 60° F., that the cold store is maintained between 0° F. and —5° F. and that the doorway is 10 ft. 6 in. high and 5 ft. 10 in. wide, the discharge slot **20** for the recirculating air curtain may be 2 in. in width and the relatively spaced discharge slot **18** for the protecting curtain may be ½ in. in width. This would be adequate to establish a double curtain of 6,750 cu. ft./min. of which 5,000 cu. ft./min. would be recirculated and 1,750 cu. ft./min. would form the protective curtain.

In this arrangement since the discharge slot **20** is considerably wider than the discharge slot **18** it is necessary that air from the slot **18** should have a higher velocity on emergence than air from slot **20** in order that the overall velocity of the protective curtain throughout the width of the doorway should be substantially the same as that of the recirculated curtain. It will be appreciated that the protecting curtain is formed by considerably less air than the recirculating curtain, whereas air from each slot **18** and **20** spreads laterally to substantially the same extent during passage across the doorway. It has been found in practice that air from the slot **18** should be given an emergent velocity higher than air from the slot **20** such that when tested independently the two curtains have substantially the same peak velocity at a position ¾ of the way across the width of the doorway from the discharge ducts **14** and **17**. The pressure ratio between the discharge ducts thus determined ensures that in operation the two curtains will have as nearly as possible the same overall velocity between the discharge and collection ducts. Entrainment, turbulence and other undesirable consequences of friction between curtains moving at different velocities are more likely to occur and are more harmful to the satisfactory operation of the apparatus nearer the collection duct **15** than the discharge ducts. For this reason the disadvantage of the discrepant emergent velocities of the curtains is unimportant compared with the advantage derived from this arrangement that in the region of the collection duct **15** the two curtains have substantially the same velocity.

A difficulty encountered in using air curtains in cold store doorways of more than minimal height is that a curtain is subjected to unequal ambient air pressures on its interior and exterior surfaces, particularly in the region of the top and the bottom of the curtain. Because of the lower temperature within the cold store hot air from outside tends to move into the store at a higher level, while cold air in consequence tends to move out of the store at a lower level. This behaviour of the ambient air tends to divert an air curtain from its proper course toward its collection duct and disrupts the proper functioning of the apparatus. This problem becomes the more acute the greater the height of the air curtain. The present invention provides means for combating this tendency so that

air curtains can be used in cold store doorways of substantial height.

In accordance with this feature of the invention the outlet slots of the discharge ducts **14** and **17** of the recirculating air curtain each comprise four longitudinally aligned nozzle sections **20** and **18** respectively (of which one nozzle section **20** is shown in FIG. 3), the outer peripheries of which are joined to the wall of the duct **14** or **17** by resilient rubber strips **23**, forming an air barrier while permitting individual angular movement of each nozzle section **20** about a vertical axis. Adjustment means **25** may be associated with each nozzle **18** and **20** to control its angular position and may comprise longitudinally extendable and retractable screw-threaded means of the conventional kind shown for instance in FIG. 3 pivoted at one end at **26** to the wall of the duct **17** and at its other end **27** to the nozzle **20.**

By means of the associated adjustment device **25** each nozzle **20** is brought into and held in the most favourable angular position for ensuring that the maximum of air discharged from the nozzles **20** reaches and is collected by the collection duct **15.** Obviously this will mean that the topmost nozzle **20** will point somewhat outwardly of the doorway, the bottommost nozzle will point somewhat inwardly of the doorway and the intermediate nozzles **20** will have a smaller angular offset from the plane of the doorway.

Another difficulty encountered in recirculating air curtains of substantial height is that the efficiency of the collection duct in collecting recirculated air and passing it back to the discharge duct proportionally diminishes as the length of the collection duct increases. In the lower portion of the collection duct remote from the connecting duct **12** turbulence is created, air is not sufficiently withdrawn from this portion of the duct, and consequently air forming the lower part of the curtain is not efficiently collected.

To overcome this drawback of recirculated curtains of substantial height the present invention provides within the collection duct **16** and intermediate its ends a booster fan unit **28** adapted to boost suction from the lower portion of the duct **16.** Surrounding the fan unit **28** and extending therefrom to the upper end of the duct **16** is a partition **29** providing a by-pass passage **30** via which air withdrawn from the lower portion of the duct **16** is passed directly to the inter-connecting duct **12** without contact with air in the upper portion of the collecting duct **16.**

An adjustable curtain separator **19** may be attached to the edge of the collecting duct **15** nearer the discharge duct **17** which skims off the outer or protective air curtain so that substantially only dehumidified air is recirculated. This separator **19** may simply be in the form of a flat or arcuate plate extending from top to bottom of the collecting duct **15** and may be hinged for movement about a vertical axis to adjust it for particular operating conditions.

With a double air curtain as described above, the inner curtain will become drier after the system commences operation as a result of exchange with the cold store air and will eventually settle down at a moisture content corresponding to equilibrium between moisture gain from the warm moist side and moisture loss to the cold store side.

The apparatus may be modified within the scope of the appended claims. For example, a drier may be incorporated in the system. Also, the curtains may pass from top to bottom of the doorway, the recirculated curtain being collected in a grille in the floor. Moreover, the fan units may be of the centrifugal or some other type instead of the axial flow fans schematically shown in FIG. 4 of the drawings.

I claim:

1. Apparatus for establishing across the door opening of a cold room an air barrier consisting of two contiguous codirectional substantially laminar air curtains on the outside of said door for the maintenance inside said room

of a substantially constant atmosphere of lower humidity and temperature than the ambient atmosphere outside said room, comprising

a self-contained duct system in the form of a unit assembly attachable to the outside of said door opening and peripherally embracing three sides of said door opening,

said duct system consisting of a first air discharge duct extending the length of one side of said door opening and having air discharge apertures adapted to blow a first substantially laminar curtain of air across said door opening and,

on the opposite side of said door opening, parallel to said first air discharge duct, an air collection duct likewise extending the length of the side of said door opening and having apertures facing the air discharge apertures of said first air discharge duct for the entry therethrough into said air collection duct of air comprising the air curtain discharged from said first air discharge duct after having traversed said door opening;

a connecting duct means between one end of said first air discharge duct and one end of said collection duct and extending adjacent one of the remaining sides of said door opening, said connecting duct means containing a blower or fan for extracting air from said collection duct and redelivering the same into said first air discharge duct;

a second air discharge duct adjacent said first air discharge duct and likewise provided with air discharge apertures adapted to blow a second substantially laminar curtain of air across said door opening in substantial contiguity and codirectionally with said first curtain of air on the outside thereof and,

associated with one end of said second air discharge duct, a blower or fan with an air intake for directly drawing in ambient air from the outside of said room and having an air outlet for delivering said outside air directly into said second air discharge duct,

said duct system being entirely devoid of devices or elements for heating or cooling air circulated or flowing through the ducts of said system.

2. Apparatus as set forth in claim 1, wherein said air discharge apertures in said second air discharge duct are of smaller cross section than said air discharge apertures in said first air discharge duct, and wherein control means are provided for at least controlling the air delivery performance of said blower or fan associated with said second air discharge duct thereby regulating the velocity of air discharge from said second air discharge duct in relation to the velocity of air discharge from said first air discharge duct.

3. Apparatus as set forth in claim 1, wherein the air discharge apertures of at least one of said air discharge ducts are nozzles adapted to be set at different selectable angles to the plane of said door opening along the length of air air discharge duct or ducts.

4. Apparatus as set forth in claim 3, wherein said nozzles communicate with the interior of said air discharge ducts through flexible sleeves and are held in position in relation to said air discharge ducts by pivoted longitudinally extendable and retractable links extending between said nozzles and said air discharge ducts for setting said nozzles to said selectable angles.

5. Apparatus for establishing across the door opening of a cold room an air barrier consisting of two contiguous codirectional substantially laminar air curtains on the outside of said door for the maintenance inside said room of a substantially constant atmosphere of lower humidity and temperature than the ambient atmosphere outside said room, comprising

a self-contained duct system in the form of a unit assembly attachable to the outside of said door opening and embracing three sides of said opening,

said duct system consisting of a first air discharge duct, open at one end and closed at the other, extending the length of one side of said door opening and having air discharge apertures or adjustable nozzles adapted to blow a first substantially laminar air curtain across said door opening, and

on the opposite side of said door opening, parallel with said first air discharge duct, an air collection duct, open at one end and closed at the other, extending the length of said door opening and having apertures facing said air discharge apertures in the said first air discharge duct for the entry therethrough into said air collection duct of air forming the curtain discharged from said first air discharge duct after having traversed said door opening;

a connecting duct means connecting the open ends of said first air discharge duct and said air collection duct and extending across the outside of one of the remaining sides of said door opening, said connecting duct means containing a blower or fan for extracting air from said collection duct and redelivering the same into said first air discharge duct;

a second air discharge duct of similar construction to said first air discharge duct extending closely adjacent said first air discharge duct on the outside thereof and likewise having one open and one closed end,

said open end of said second air discharge duct communicating with the delivery opening of a blower or fan which draws in air directly from the ambient atmosphere and directly delivers said air into said second air discharge duct which discharges said air in the form of a second laminar curtain of air in substantial contiguity and codirectional with said first curtain of air across and past said door opening,

said two air discharge ducts and the said collection duct having an internal cross section which diminishes from the closed to the open ends of said ducts and

the entire duct system being devoid of devices or elements for heating or cooling air circulated or flowing through the ducts of said duct system.

6. Apparatus for establishing across the door opening of a cold room an air barrier consisting of two contiguous codirectional substantially laminar air curtains on the outside of said door for the maintenance inside said room of a substantially constant atmosphere of lower humidity and temperature than the ambient atmosphere outside said room, comprising

a self-contained duct system in the form of a unit assembly attachable to the outside of said door opening and embracing three sides of said opening,

said duct system comprising on one side of said door opening an inner and an outer elongated air discharge duct extending in side-by-side adjacence along the length of said side of said door opening and each having discharge apertures adapted to blow one of two substantially contiguous codirectional air curtains across said door opening;

on the opposite side of said door opening a single air collection duct with air entry apertures adapted to collect substantially only the air of the air curtain discharged from the inner of said two discharge ducts and to direct said air towards one end of said collection duct for recirculation through a connecting duct, which is not exposed to heating or cooling effects and contains a blower or fan, back into said inner air discharge duct;

said collection duct further containing within its interior in a position intermediate its ends a booster fan for boosting return of the collected air to said recirculating connecting duct,

and partition means between said booster fan and said recirculating connecting duct,

the outer air discharge duct being associated with a blower or fan for the continuous and direct supply to said outer air discharge duct of air drawn directly

from the atmosphere outside said room to form the other of said two air curtains from non-recirculated ambient air.

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