Nov. 6, 1934. J. W. SANFORD 1,979,286

COMPRESSOR

Filed Jan. 24, 1931 2 Sheets-Sheet 1

Fig. 1.

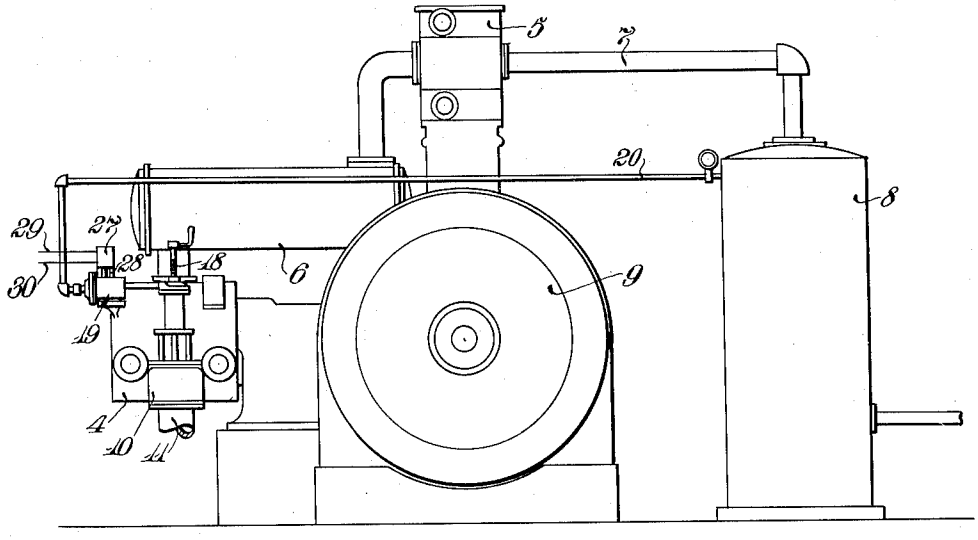

Fig. 2.

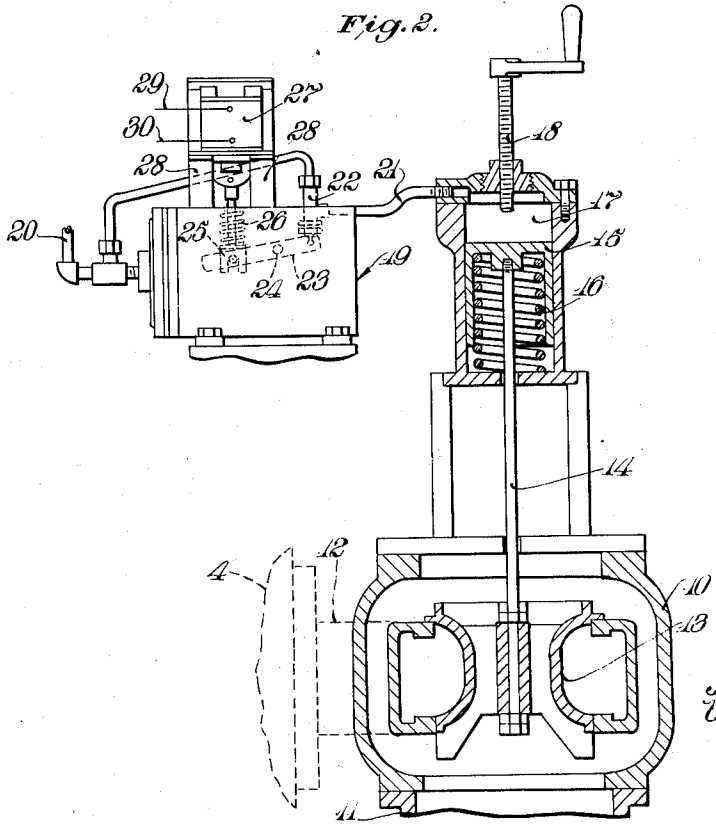

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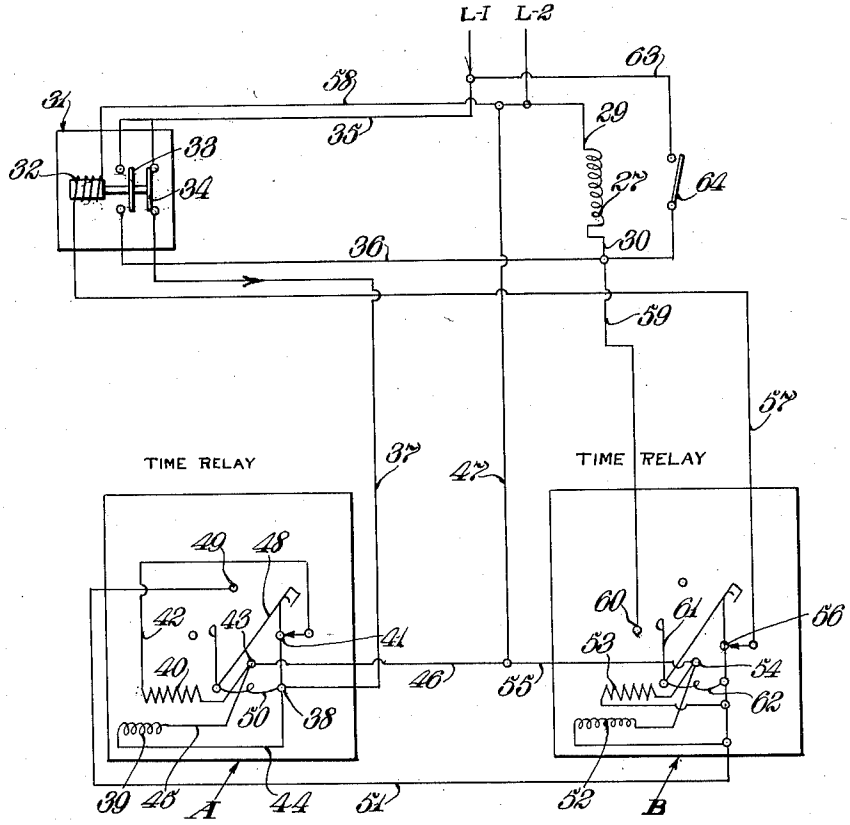
Fig. 3.



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UNITED STATES PATENT OFFICE

1,979,286

COMPRESSOR

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Application January 24, 1931, Serial No. 510,936

24 Claims. (Cl. 230—4)

My invention relates to load controlling devices generally, and more particularly to means for limiting the load on a compressor to a predetermined percentage of full load.

It is an object of my invention to provide improved means for controlling the load placed on a motor by a machine driven thereby. A further object is to provide improved electrically operated timing devices for limiting the average load placed on a driving motor by a machine driven thereby. Still another object is to provide an improved automatic compressor control system whereby the average load on the compressor may be limited to a predetermined percentage of full load when desired.

When compressors are driven by electric motors it becomes important to reduce the cost of electric energy required for producing the compressed air to a minimum. The rate charged by some of the power companies is based on the maximum load demand over a specified interval of time, usually four minutes to thirty minutes. With unloading mechanisms of the type heretofore used for automatically loading and unloading the compressor in response to variations in demand for compressed fluid, the compressor and its driving motor may sometimes be caused to run under full load for an interval which may be longer than the maximum demand interval specified by the power company as its basis for rates. This is due to the fact that the usual unloaders operate in response to receiver tank pressure without regard to the power being supplied to the driving motor. It is also a fact in many installations of one or more compressors that the total capacity may be as much as two or three times the average demand for compressed air in order to take care of peak requirements. The inconvenience which might be caused to the user of compressed air if the compressor output were materially limited at a certain time of the day would not be great as compared to the saving in the power bill which might result. Some of the power companies impose a decided penalty on maximum demands for a given interval of time at certain hours of the day, for example, around four to six P. M. In compressor installations at mines where compressed air is employed for operating rock drills and other pneumatic equipment, a reduction of pressure even to seventy-five percent of the normal pressure for a fraction of the day would not be at all serious and it is more important to avoid the penalty imposed on a peak load between four and six P. M. It is therefore one of the primary objects of my invention to provide improved mechanism for controlling a compressor to meet the above conditions, which shall be accurate and of rugged construction. A still further object is to provide improved means for varying the maximum load upon a compressor over a certain predetermined time interval and to provide means for regulating said time interval and for varying the limiting load. Other objects and advantages of my invention will appear during the course of the following specification and claims.

In the accompanying drawings I have shown for purposes of illustration one form which my invention may assume in practice.

In these drawings,—

Fig. 1 is a diagrammatic view in elevation of parts of a compressor system with which my improved control mechanism may be associated.

Fig. 2 is also a diagrammatic view illustrating an unloader in section and the pilot valve and associated mechanism in elevation.

Fig. 3 is a wiring diagram of the electrical load control apparatus, in an illustrative form.

In carrying out my invention I employ preferably the usual elements of a common type of unloading system involving the use of a fluid actuated total closure intake unloader controlled by a pilot valve. The pilot valve is designed to operate normally in response to receiver tank pressure to load and unload the compressor, and the function of the pilot valve in unloading the compressor on a predetermined high receiver tank pressure is not interfered with by the addition of the mechanism of my invention. For the purpose of securing a control of the unloaders, a solenoid and spring actuated locking element, as disclosed in my copending application Serial No. 262,520, filed March 17, 1928, now Patent No. 1,786,128, may be used. It will be noted that by the use of the mechanism disclosed in said application, the pilot valve is locked in unloaded position at such times as the solenoid is deenergized and is permitted to function normally to load or unload the compressor whenever the solenoid is energized. My invention contemplates the use of two electrically operated adjustable definite time relays for controlling the energizing circuit of this solenoid so as to cause the same to be alternately energized and deenergized, the period of energization being regulated by the adjustment of one relay, while the period of deenergization is regulated by the other relay. It will thus be seen that the compressor may be unloaded at specified times independent of receiver tank pressure.

Referring to the specific embodiment of my invention illustrated in the drawings, there is shown in Fig. 1 a compressor of the angle compound type having a low pressure cylinder 4 and a high pressure cylinder 5 with an intercooler 6 interposed between the two cylinders. Compressed fluid is discharged from the high pressure cylinder through a line 7 to a usual receiver tank 8. Since the specific construction of the compressor driving motor does not enter into the present invention, it has not been shown in detail, but a direct connected motor is indicated at 9. The

unloader illustrated is of the total closure intake type having a casing 10 to which fluid to be compressed is supplied directly from the atmosphere or through a suitable pipe connection 11. Fluid is supplied from this casing to the compressor through a connection 12 under the control of a double seat valve element 13 which is actuated through a stem 14 and piston 15. The valve is normally held in its upper or loaded position by means of a spring 16, thereby permitting fluid to flow freely to the intake of the compressor. The unloader valve is actuated to closed or unloaded position by fluid pressure acting in the cylinder 17 and the amount of movement of this piston is controlled by an adjustable stop 18. For the purpose of controlling pressure in the unloader cylinder 17, my improved control system includes a usual pilot valve mechanism generally indicated at 19 which may be of any of the well known types, the one herein illustrated being of the type known as the Penn pilot valve and more fully illustrated in my Patent No. 1,786,128. This pilot valve mechanism operates in a well known manner in response to a predetermined high pressure in the receiver tank 8, with which it is connected by a line 20, to establish a connection between the receiver tank and the unloader by way of a pipe 21 leading from a three-way valve mechanism 22 on the unloader. The compressor discharge pressure responsive pilot valve mechanism includes a lever 23 pivoted at 24 which operates on the three-way valve 22 to connect the unloader with the receiver or vent the same to atmosphere. Controlling movements of the lever 23 are normally automatically effected in response to variations in the compressor discharge pressure, except when a superior control in accordance with my invention is effected. Clockwise movement of the lever from the position in Fig. 2 effects loading. It will of course be understood that when my invention is applied to a compound compressor, any suitable type of unloading system may be used to unload the high pressure cylinder. If desired, a fluid pressure actuated relief valve mechanism for the high pressure cylinder may be connected also to line 21.

As disclosed in the aforesaid application, I have devised a locking element 25 actuated by a spring 26 engaging lever 23 and locking the valve 22 in unloading position. For the purpose of retracting this locking element against the force of spring 26, I have attached a suitable solenoid having a coil 27 supported on the pilot valve mechanism by brackets 28 and when this solenoid is energized, the locking element 25 is pulled out of engagement with lever 23, permitting the pilot valve to function normally to load and unload the compressor dependent on receiver tank pressure. In Figs. 1 and 2 I have shown lines 29 and 30 leading to the solenoid and adapted to be connected with a source of power through the illustrative form of my improved controlling apparatus which will now be described.

In the wiring diagram of Fig. 3 the solenoid coil 27 is shown at the upper right hand part of the figure and a suitable source of power indicated at L1, L2. The circuit through solenoid coil 27 is controlled directly by a two-pole magnetically operated switch generally designated 31 which has a coil 32 for controlling two switch elements 33 and 34 normally open and closed respectively. The normally open contact member 33 of this switch controls the solenoid circuit and when it is closed by energization of coil 32, current flows from L1 through lines 35, 36 and 30, coil 27 and line 29 to L2. For the purpose of controlling current through coil 32 I have shown in the illustrative embodiment disclosed herein a system involving, for convenience in construction, two adjustable definite time relays generally designated A and B, and the specific mechanical construction of these relays has not been illustrated since such relays are well known in the electrical engineering arts and their structural details do not enter into the present invention. Some of the large manufacturers of electrical equipment have on the market a relay which will accomplish the desired functions. These units may be accurately timed and are of rugged construction so that they are very dependable over a long period of time. Relays A and B are identical in construction and each has a coil adapted when energized to close a switch and a small motor which when energized trips after a definite time delay a pair of switch elements which are respectively adapted for opening a circuit at one contact and closing a circuit at another. When deenergized, the mechanism of the relay automatically resets itself immediately. Certain capabilities of these relays are not employed in the system illustrated, but the convenience of using standard commercial units has led to their selection in the illustrative system.

With the parts in the position shown, current is passing from L1 through line 35 and switch element 34 of the automatic switch, line 37 leading to terminal 38 on relay A. Coils 39 and 40, the latter of which designates the motor in relay A, are energized by parallel circuits one of which leads from terminal 38 through the normally closed contactor 41 of relay A which connects to 40 through a line 42, and thence to terminal 43 of the relay, and coil 39 is connected across terminals 38 and 43 by wires 44 and 45. The circuit is completed back to L2 from terminal 43 by wires 46 and 47. It will be noted that at this time the circuit through coil 27 of the solenoid controlling the unloader is open whereby the pilot valve is locked in unloaded position. After a definite time interval, relay A will trip and the switch element 48 will close a circuit at contact 49. Power now flows from L1 through 35, switch 34, 37, 38, connection 50, switch 48, 49, through line 51, and coil 52 and motor 53 of relay B are energized from 51 across to terminal 54, line 55 and line 47 to L2. Simultaneously the holding coil 32 of the double pole switch is energized by power from 51 through contact 56, line 57 and back to L2 through the coil and line 58. When the holding coil 32 is energized, contact member 33 of the double pole switch will close and 34 open. Power now flows from L1 through pole 33, line 36, thereby energizing coil 27 on the unloader pilot valve, and also through line 59 to terminal 60 on relay B. Immediately on energization of relay B, switch 61 has closed, thereby completing a circuit through the holding coil 32 by way of connections 62, contact 56, line 57, coil 32 and back to L2 through line 58. At the time of energizing holding coil 32, relay A is completely deenergized due to opening of contact member 34 and is immediately reset automatically. At the time of change in position of the double pole switch, the energizing circuit for relay B is broken at contact member 34, but immediately completed again at contact member 33 by power passing from L1 through 33, line 36, 59, 60, 61, 62, and through coil 52 and motor 53 in parallel to line 55 and 47 back to L2. Now a definite time after relay B has been energized,

the holding circuit for coil 32 will be broken at contact 56 and the double pole switch will return to its initial position as illustrated in the drawings. This deenergizes coil 27 on the pilot valve of the unloader and relay B is also deenergized by opening of circuit at contact member 33 and it returns to initial position. Contact member 34 now causes energization of relay A and the same cycle of operations is repeated over and over.

These relays can be set to trip at any desired time interval and the setting of relay A will control the length of the unloaded period and the setting of relay B will govern the length of the loaded period. By adjusting these relays in any desired manner the proportion of time unloaded to time loaded may be varied as well as the total length of time required for completion of a cycle of operations.

The operation of the wiring diagram has already been set forth in conjunction with the description of the different units and connections, and operation of the mechanism shown in Fig. 2 will be readily apparent in view of the above description of the structure.

As a result of my invention it will be evident that improved electrical means have been devised for regulating the maximum average load which may be placed on the compressor and this maximum average may be adjusted to suit different conditions. For example, if it is desired to maintain the peak load at a certain time of the day below fifty percent of the total capacity of the compressor, the relays will be set to trip at equal intervals and thereby ensure that the compressor run completely unloaded half of the time. The integrated power curve over an interval which may be specified by the power company will therefore be materially reduced and the penalty imposed by a peak load at this time of the day will be avoided. Whenever it is desired to cut out the operation of the definite time relays and permit the compressor installation to have a total capacity output, it will be obvious that the solenoid on the unloader pilot valve may be continuously energized by a simple connection such as indicated at 63 for connecting coil 27 directly across L1, L2, control being effected by any suitable switch as indicated at 64. It is to be understood that my invention is not limited to the specific arrangement of equipment involving two definite time relays and a double pole switch for controlling the circuit through the solenoid 27. No doubt, other electrically operated timing devices functioning for example on a principle somewhat analogous to devices for controlling traffic signals or fire alarms may be satisfactorily worked out which will accomplish the desired result.

While I have in this application specifically described one form which my invention may assume in practice, it will be understood that this form of the same is shown for purposes of illustration and that the invention may be modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In combination, a power consuming device, a driving motor therefor, means for varying the power required to drive said device, and means including electrically operated timing devices cooperating with said power varying means and respectively controlling the duration of increased and of reduced power demand for automatically periodically reducing the load on said motor to a minimum over predetermined time intervals.

2. In combination, a power consuming device, a driving motor therefor, means for automatically varying the power required to drive said device, and means including electrically operated timing devices cooperating with said power varying means and respectively controlling the duration of increased and of reduced power demand for automatically periodically reducing the load on said motor to a minimum over predetermined time intervals.

3. In combination, a power consuming device, a driving motor therefor, means for varying the power required to drive said device, and means including independently adjustable electrically operated timing devices cooperating with said power varying means and respectively controlling the duration of increased and of reduced power demand for automatically periodically relucing the load on said motor to a minimum over predetermined time intervals.

4. In combination, a power consuming device, a driving motor therefor, fluid pressure operated means for varying the power required to drive the device including an automatic device for controlling said fluid pressure operated means in accordance with the demand imposed on said power consuming device, and electrical means for controlling said automatic device automatically operative to limit the average power required by said power consuming device over a predetermined time interval to a predetermined percentage of full load.

5. In combination, a machine, a motor for driving the same, means for changing the load on said motor caused by said machine having a control means automatically operative to preclude load in excess of a predetermined maximum, an electrically operated device for controlling said automatically operative control means, and controlling means for said electrically operated device automatically operative to limit the average load over a certain time interval to a predetermined percentage of full load.

6. In combination, a machine, an electric motor for driving the same, means for varying the power required to drive said machine, an electromagnetic device for controlling said power varying means operative when deenergized to reduce the load, and when energized to permit an increase in load, a circuit through said electromagnetic device, and automatic means for controlling said circuit to limit the average load to a predetermined percentage of full load.

7. The combination specified in claim 6 wherein there is further provided manually controlled means for selectively effecting continuous energization of said electro-magnetic device independently of said automatic circuit controlling means.

8. In combination, a machine, a motor for driving the same, means for varying the load on said motor due to said machine, an electromagnetic device for controlling said means to effect variation in load when energized and deenergized, a circuit for controlling energization of said device, and automatic control means for said circuit for periodically effecting energization and deenergization of said device whereby the average load on said motor is maintained below a predetermined value.

9. The combination specified in claim 8 wherein the automatic circuit control means comprises

timing mechanism for alternately opening and closing said circuit.

10. The combination specified in claim 8 wherein the automatic circuit control means comprises electrically operated timing mechanism for alternately opening and closing said circuit.

11. The combination specified in claim 8 wherein the automatic circuit control means includes two definite time relays interconnected with each other and with said electromagnetic load control device.

12. The combination specified in claim 8 wherein the automatic circuit control means includes two electrically operated definite time relays one of which is set to control the period when said circuit is open and the load on the motor reduced, and the other of which is set to control the period when said circuit is closed and the load permitted to be increased.

13. In a compressor control system, a compressor, unloading means for automatically effecting loading and unloading of said compressor in response to variations in compressor discharge pressure and including a compressor discharge pressure responsive pilot mechanism, and electrically operated means acting through said pilot mechanism for automatically effecting unloading of said compressor, while the latter continues to run at normal speed, independently of compressor discharge pressure.

14. In a compressor control system, a compressor, unloading means for automatically controlling the load on said compressor in response to variations in compressor discharge pressure including a compressor discharge pressure responsive pilot mechanism, and electrically operated means acting through said pilot mechanism for automatically limiting the average load on said compressor to a predetermined percentage of full load independently of compressor discharge pressure while the compressor is running at normal speed.

15. In a compressor control system, a compressor, unloading means for unloading said compressor in response to a predetermined high receiver tank pressure including a receiver tank pressure responsive pilot mechanism, and means for limiting the maximum average load of said compressor over a predetermined time interval to a fraction of full load, including electrically operated mechanism acting through said receiver tank pressure responsive pilot mechanism for holding said compressor completely unloaded for a portion of said interval.

16. In a compressor control system, a compressor, an unloading device for unloading said compressor when subjected to pressure, a pilot valve for controlling said unloading device to load and unload the compressor in response to receiver tank pressure, means for controlling said pilot valve to hold the compressor unloaded independently of receiver tank pressure, electromagnetic means for releasing said holding means, and a timing mechanism for controlling the circuit through said electromagnetic means for limiting the maximum average load on said compressor over a predetermined time interval.

17. In a compressor control system, the combination specified in claim 16 wherein said timing mechanism includes electrically operated time relays for controlling the circuit through said electromagnetic means.

18. In a compressor control system, the combination specified in claim 16 wherein said timing mechanism comprises a plurality of electrically operated definite time relays and a two-pole automatic switch, said relays and switch being interconnected with each other and with said electromagnetic means whereby the circuit through said electromagnetic means is opened and closed at predetermined time intervals for limiting the maximum average load on said compressor.

19. In a compressor control system, the combination specified in claim 16 wherein said timing mechanism is electrically operated and includes means for varying the proportion of time when said circuit is closed to the time when said circuit is open.

20. In a compressor control system, a compressor, an unloading device for unloading said compressor when subjected to pressure, a pilot valve for controlling said unloading device for normally loading and unloading the compressor when subjected to pressure, means for locking said pilot valve in unloaded position, electromagnetic means for releasing said locking means when energized, and electrically operated timing mechanism functioning automatically to open and close the circuit through said electromagnetic means intermittently at predetermined time intervals.

21. In a compressor control system involving the combination specified in claim 20, a circuit for selectively effecting continuous energization of said electromagnetic means and a manually controlled switch in said circuit.

22. In a compressor control system, a compressor, an unloading device for unloading said compressor when subjected to pressure, a pilot valve for controlling said unloading device functioning normally to load and unload the compressor in response to receiver tank pressure, a device for holding said pilot valve in unloaded position, a solenoid for releasing said holding means when energized, automatic electrically controlled means for alternately opening and closing a circuit through said solenoid comprising a double pole switch for directly controlling the circuit through said solenoid, a pair of adjustable time relays one of which is set to control the period during which said circuit is closed and the other controlling the period when said circuit is open, means controlled by said double pole switch for energizing one of said relays, means controlled by such relay for controlling energization of the other relay, and electromagnetic means for actuating said double pole switch in turn controlled by said relays.

23. In combination, apparatus constituting a load, a driving motor therefor, means associated with said apparatus for varying the load which it presents, and means for automatically periodically controlling said load varying means to provide alternate periods of increased and diminished load having provision for varying the duration of the periods of increased load while leaving the periods of diminished load the same.

24. In combination, apparatus constituting a load, a driving motor therefor, means associated with said apparatus for varying the load which it presents, and means for automatically periodically controlling said load varying means to provide alternate periods of increased and diminished load having provision for varying the duration of the periods of diminished load while leaving the periods of increased load the same.

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