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PROJECT NO. 785-B
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SIGNED W. Douglas Beers
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In Project 785-B memoranda dated April 6 and 24, Mr. Rammer had described the Large Room and Small Room air conditioning systems as they are now constituted.

The addition of the dry bulb submaster thermostat T_4 in the Large Room system provided adequate control of the return air temperature, which, in conjunction with the already stable return air wet bulb control provided adequate control of the relative humidity. The replacement of steam with hot water in one of the reheat coils provided smooth control of small amounts of reheat and provided a reservoir of reheat to preserve control in the event of a temporary steam failure. The introduction of a dampered bypass regulated by the dry bulb submaster T_4 assured that minimums of refrigeration and reheat would be required.

The installation of baffles in the supply air duct and the speeding up of the fan (3-1/2-inch motor pulley replaced by 4-1/2-inch motor pulley) were intended to reduce the differences in temperature which often prevail between the east and the west end of the Large Room. This problem has continued in spite of these efforts; there is evidence indicating that the non-uniform room temperatures are related to the non-uniform floor temperatures which, in turn, are the result of non-uniform basement temperatures.

Although the greater fan speed results in more infiltration on the suction side of the fan (plenum chamber, etc.), this should not considerably increase the refrigeration load unless the amount of summer ventilation is excessive. If the summer ventilation were excessive even when the return air dampers are wide open and the fresh air intake dampers are allowed to close completely, then the fan should be slowed by the reinstallation of the 3-1/2-inch drive pulley (flow reduced from 7500 to 5500 cfm).

It is noteworthy that the automatic bypass allows extra air flow without the extra refrigeration and reheat which usually result from having to cool the extra air to the dew point and then reheat it to the supply temperature. However, inasmuch as the automatic bypass has not completely eliminated reheat during the summer-like days of the current month, it is apparent that some refrigeration and reheat is still being wasted (too much air flowing through the spray chamber). For this reason, the writer recommends that the 4-1/2-inch fan motor pulley be replaced by the original 3-1/2-inch fan motor pulley.

The replacement of the original snap-action relay arrangement with a fresh air thermostat <u>gradually</u> closing the fresh air intakes at excessively high fresh air temperatures has served two purposes: (1) The fresh air and the refrigeration can be used <u>together</u> when the fresh air does not completely eliminate the refrigeration load, and (2) the changeover from full fresh air to minimum fresh air flow does not upset the control as the snap-action relay repeatedly did. Thus, the benefit of <u>smooth</u>, <u>reliable</u> and <u>less expensive</u> operation was gained. Fresh air as warm as 57° F. (50% R.H., 73° F. room) is now used to advantage. This rearrangement was completed during the winter and it was not until the last week of April that <u>any</u> refrigeration was required.

A system more completely utilizing the principles applied to the Large Room system is described in an invention record entitled, "System for Full Utilization of Fresh Air, Refrigeration, and Heating in Automatic Control of Air Temperature and Humidity". The writer suggests that the simple thermostat now used to close the Large Room fresh air intake above 57° F. be replaced by a wet bulb thermostat (same simple thermostat with wet wick arranged on the bulb) or by a submaster thermostat reset by a humidostat. The writer does not know of a commercially available humidostat having as wide a throttling range as this application requires. A throttling range as wide as 80% R.H. could be used (relative humidity in Appleton is "never" below 20%). However, a throttling range of 60% R.H. would be sufficient to extend the use of fresh air to 76° F. (40% R.H.) by increasing the control temperature of the submaster thermostat one Fahrenheit degree from 52° F. for each 2.5% R.H. below 100% R.H. An examination of the pychrometric records of the months of May, June, July, August and September for the several years when these records were kept for outside air would reveal the magnitude of the saving which would be realized by the addition of a wet bulb or humidostatic reset in the fresh air selection device.

The efforts made to improve the control of the Small Room system have been less fruitful, but some of the changes seem worth mentioning. The addition of thermostatic control of the afterdrier cooling water valves saves very large amounts of water without sacrificing the availability of cooling capacity. The writer believes that this additional "steadying force" will also contribute strongly to the final solution of this control problem.

The installation of a snap-action relay to close the high-pressure steam valve at the drier regeneration air heater before the drier blower stops running has eliminated the over-heating of the regeneration air intake and has provided a means of achieving considerable savings in regeneration steam. However, with the arrangement described in Mr. Rammer's memorandum of April 24, the drier operated much of the time with the regeneration steam valve closed. Although it thus appeared that the relay was accomplishing great savings of steam, it was perceived that when the drier operated with the regeneration steam valve closed, 1600 c.f.m. of unheated basement air was still being drawn across the adsorption beds and that this probably resulted in degeneration of those beds, the drier being used to dry the air exhausted from the basement. This resulted in extra openings of the regeneration steam valve and in correspondingly greater cooling requirements. Therefore, the sequence of the wet bulb submaster(H_1) controlled action was changed so that as the wet bulb submaster (H_1) control air pressure falls from 12 to 9 psig., the humidifier steam valve closes, from 6 to 0 psig. the afterdrier damper opens, at 4 psig. the fresh air intake damper is closed, the drier motors start and the regeneration steam valve opens, from 3 to 0 psig. the bypass damper closes. As the wet bulb submaster control air pressure rises from 0 to 3 psig., the bypass damper opens, from 0 to 6 psig. the afterdrier damper closes, at 6.5 psig. the fresh air intake damper is put under dry bulb submaster control, at 6.7 psig. the regeneration steam valve closes, at 8 psig. the drier motors stop, and from 11 to 14 psig. the humidifier steam valve opens. It is expected that this will allow less degeneration of the drier (thus conserving steam and cooling water) without overheating the regeneration air intake or reducing the quality of control.

The installation of submaster thermostat T_4 and submaster humidostat H_1 has provided means of achieving smooth, reliable control but, as yet, such control has required the expensive practice of "bucking" heating against cooling so that both are wasted and humidifying against drying so that both are wasted.

The goal toward which the improvement of the small room system should be aimed is, in the opinion of the writer, the arrangement whereby smooth, reliable and least expensive operation is achieved. Essentially, this requires that: (1) Maximum use be made of fresh air to eliminate the need for drying, cooling, or heating (humidifying not a considerable expense when the other operations are efficient), (2) refrigeration never occur simultaneously or in rapid alternation ("hunting" or "cycling") with heating, (3) heating never occur simultaneously or in rapid alternation with drying (air from drier should be hot enough that only cooling is required), (4) heating never occur simultaneously or in rapid alternation with use of fresh air for cooling, and (5) drying never occur simultaneously or in rapid alternation with humidifying.

The present arrangement of the Small Room system suits these principles except for the fresh air selection device discussed below. However, the control is not smooth when drying or refrigeration are required. The writer is reasonably certain that this will improve when the 10 H.P. refrigerator is replaced by the 3 H.P. refrigerator;

then the supply air temperature will be more steady and the submaster humidostat will not be upset as it now is by the wide supply temperature fluxuations.

The present arrangement for selecting fresh air is not satisfactory. The writer suggests that the snap-action relay R_2 now involved in the fresh air selection be removed from this application (plug the line now connected to port 1 and connect to each other the lines now connected to ports 2 and 4) and that the 10 to 40° F. L0900 now in temporary use as T_3 be installed as the fresh air selection device T_2 as soon as the 60 to 85° F. L090C is returned for service as T_3. Used as T_2, the 10 to 40° F. L0900 (with proper spring) will have its bulb in the fresh air intake upstream from the fresh air damper M_1 and will be connected at its "main" (M) port to the dry bulb submaster line connected to PE_1 and V_4. The "branch" (B) port of T_2 will be connected to the pilot (P) port of M_1; the "main" (M) port of M_1 will be connected to the 15 psig. air main. T_2 will be reverse-acting and will have a control temperature of 40° F. (33% R.H., 73° F. room) with the minimum throttling range (3 F. degrees). As the dry bulb submaster pressure varies, V_4 will close from 1 to 8 psig. open from 7 to 0 psig., M_1 will open from 8 to 14 psig, close from 13 to 7 psig. (T_2 allowing), and PE_1 will start the compressor at 13 psig., stop it at 12 psig.

It may be noted that when T_2 eliminates the action of M_1, there is a "dead spot" from 8 to 13 and from 12 to 7 psig. in the dry bulb submaster control. If this were objectionable, the throttling range of T_2 might be increased to make the shutting of the fresh air damper more gradual. As a last resort, a system of relays might be improvised to shift the refrigerator control from 13-12 to 9-8 psig. when the fresh air damper closes. The writer doubts that this would prove more satisfactory than the arrangement suggested. The writer anticipates that with fresh air temperatures near 40° F., the dry bulb submaster pressure will be near 10 psig. and that, as the fresh air temperature rises and the fresh air damper is gradually closed, the pressure will rise to be near 12 psig. If the fresh air temperature continues to rise, then the dry bulb submaster pressure will rise to 13 psig. and refrigeration will begin. This action would be reversed with a falling fresh air temperature.

In order to more fully utilize fresh air, the writer suggests that the previously mentioned 10 to 40° F. L0900 (T_2) be replaced by a submaster thermostat reset by a humidostat so as to extend the use of fresh air up to 70° F. (40% R.H.). The control point of this submaster thermostat should be raised one Fahrenheit degree from 40° F. for each 2% R.H. below 100% R. H. and should not be raised past 70° F. (humidostat throttling range of 60% R.H.).

If merely changing the refrigeration from 10 to 3 H.P. fails to smooth the summer control of the supply temperature, modulation of the refrigeration (according to the dry bulb submaster pressure) might be necessary. This might be done with a back pressure regulator valve as shown in Figure 8 on page 7 of Johnson Service Company Apparatus Bulletin R 870. However, the writer would favor the modulation of the expansion valve as shown in Johnson Service Company Apparatus Bulletin V 306. If the 9 to 13 psig. modulation mentioned were used, this would necessitate reducing the operating ranges of V_4 and M_1 to 0 to 5 psig. and 5 to 10 psig. respectively (PE_1 would start compressor at 10 psig.), or would necessitate the use of a relay to convert the 13 to 15 psig. signal now available for refrigeration control to 9 to 13 psig.

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