CAPACITOR

Two capacitors are used in C. S. R. and only one in P. S. C. The start capacitor works momentarily at the start and then just idles and therefore need not necessarily be metal cased. It is generally paper capacitor of the requisite Micro-Farad Capacity and voltage, depending upon the motor windings to suit, which the manufacturers themselves are expected to specify correctly.

Similar specifications are also to be mentioned in the case of RUN Capacitor, which should be robust, metal clad and oil filled as it stays on in the circuit both in P. S. C. and C. S. R. as long as the Compressor runs.

Instances of capacitor bursting out due to wrong selection or faulty use is not unknown to some users and many service personnel.

Standard tests are available for checking and testing these capacitors and actual capacity may be determined by the Impedence Bridge or Calculated from the independence obtained from direct readings of an ammeter when rated voltage at the rated frequency is applied against its terminals.

The capacitors though static in operation, their function should not be minimised.

SEALED COMPRESSOR

It is the heart of the Air Conditioner, the costliest among all other components, the most expensive on repairs, and therefore deserve detailed treatment.

It is also called the "heat pump" signifying that it helps pumping out heat from the room in an Air Conditioner and in all other application, from one region of the appliance to another. This is a combination of the drive (motor) and the driven (compressor) on a common rotating shaft (rotor shaft and the crank shaft) charged with lubricating and cooling oil, encased in a mild steel shell in two parts welded together, through one of which electrical terminal, heat proof and pressure proof and having high dielectric strength, comes out. The entire assembly inside, is often internally suspended on springs and externally, the shell rests on rubber gromets of requisite compressibility. The order of cushioning is reversed in some cases, that is, the assembly rests inside on a suitable neoprene rubber and externally, the casing sits smugly on springs. The latter is generally favoured because in case of spring failure (neoprene Rubber failure does not occur in a hurry or too soon) located outside can easily be detected, which is not possible in the case of internal spring suspension, unless cut open.

Whereas suspension is a matter of urgent consideration for the manufacturers of hermetically sealed compressors, the manufacturers of Air Conditioners should see that it is mounted parallel to the plumb line in case of vertical compressor and spirit level in case of horizontal compressors and in both cases the mounting should be firmly held, allowing for natural vibration, caused or generated, when the Compressor runs.

During the operation, the moving parts are force lubricated by means of a built-in small oil pump and the motor windings partially cooled with the return gas entering the shell through the suction pipe. It should be borne in mind that this gas plays the least part in cooling the Compressor, oil does the cooling.

This is just another compressor, though different from an air compressor, in constructional details.

The parts like crank case, crank shaft, bearings, piston, cylinder, connecting Rod, gudgeon pins, piston Rings Suction and discharge valves, mufflers, cylinder head etc. exist as in any reciprocating compressor. The rotor of the motor takes place of the Fly Wheel and the counterweight is often placed on the rotor, though, in many cases on the crank shaft itself.

There are two ways of sealing the electrical terminals coming out of the compressor for making connections outside. A built-in fusite terminal assembly is welded on to the casing and in the second case, terminal studs are sealed with tight fitting neoprene rubber tubes, held in position by suitable washers and screws. The neoprene rubber absorbs mechanical shocks and the wire can be screwed on. It often has long life, extending upto seven years, which came to the notice of the author. Fusite can last longer but being brittle is prone to accidental damage, wire cannot be screwed on, nor can be soldered. The difficulty is that the connections is to be made with clips, which unfortunately, often comes out. These are the main disadvantages of fusite terminals.

There still exists controversy about the number of cylinders the sealed compressor should have. It had been almost universal practice upto about fifteen years ago, adopted by manufacturers the world over, to have two cylinders (and two pistons) for 1 Ton (R) to 2 Ton (R) running at 1400—1460 R. P. M. range for 50 cycles and 1700—1760 R. P. M. range for 60 cycles.

In a twin cylinder compressor, the moving parts to be perfectly aligned and perfectly balanced are :—

Shaft bearings — 2 Nos.

Big end connecting rod bearings — 2 Nos.

Small end connecting rod bearings — 2 Nos.

Piston Pins — 2 Nos.

Piston and cylinder contact movement - 2 Nos. Total-10

It demands highly precision machining and grinding to very close tolerances to attain concentricity and avoid ovality. To reduce the number of such operations manufacturers then decided to run the compressor on a single cylinder with the objective of cutting down the number of such parts and a single cylinder obviously requires.

Shaft bearings — 2 Nos.

Big end connecting rod bearing — I No.

Small end connecting rod bearing — 1 No.

Piston Pin — 1 No.

Piston and cylinder contact movement - 1 No. Total - 6

The volumetric displacement of course remained the same though its efficiency suffered to an extent. There is a saving of four vital alignments to be taken care of. It is reasonable but the speed of the compressor is enhanced to 2800—2850 R. P. M. for 50 cycles supply and to 3500—3560 R. P. M. range for 60 cycles. The twin cylinder compressors had 4 — Pole single phase motors against single cylinder having 2 — Pole single phase motors.

In the latter case there is two fold saving in labour and material for the compressor and the motor portions, against 4 — Pole construction. No Engineer with his reasoning

and experience would mind these savings, but on the contrary, welcome it wholeheartedly. But in the present case the saving is achieved at the cost of life and reliability of the compressor detriment to the interest of the customer. It does not need any specialised knowledge to foresee that moving parts with higher speed would wear away sooner and cause bigger problem of dynamically balancing and this is precisely what is happening to single cylinder high speed compressor. An example, though not strictly similar, may be cited. A I00Ton 450 R. P. M. Compressor installed in a cinema house about four decades ago, is rendering remarkable service till this day.

In India the twin cylinder imported sealed compressor used to carry with it manufacturers' warranty of full five years, which has been reduced for compressors manufactured in India, mostly with single cylinder and 2 Pole motors, to only one year.

Should we show scant attention to the customer's money, who pays through his nose in the price of Air Conditioner, its central excise duty and local Sales Tax ? Certainly, he deserves more consideration, whether the buyer is the Government or an organisation or Institution or a private individual.

Technological convenience coupled with profit motive may be conceded upto a certain limit, without jeopardising the interest of the buyer, compatible to the above factors, we should have a single cylinder compressor but with 4—Pole single phase motor, which will have easier machining and grinding operations, combined with a slower speed of 1400—1450 R. P. M. range, would reduce the magnitude of the problem of wear noise and vibration. The cost of the motor portion would increase, however, to some extent due to extra winding wire and lamination to be used.

The manufacturers of sealed compressors in their own enlightened interest, all over, should consider this as otherwise, it would be forced upon them by the customers one day. By the way, it is not clear why the manufacturers of these items do not extend 5 years warranty, if they are sure of their Product and faith in their collaborators.

It is no use following a hush hush policy. Let us face facts and find the correct remedy, if we want the industry survive and grow.

The heart of the machine should really be sound to avoid costly transplantation too frequently. The manufacturers bear the burden just for one year, leaving the customer to fend for himself after that and as long as the machine is in use. The exasperated customers one day may force the hands of the Government for liberalisation of import, when the protective Indian market would cease. It should be borne in mind.

Let us accept the Indian market and conditions as they exist and produce the best. Even in the market outside India 4—Pole single cylinder compressor would be appreciated by whosoever may use it.

The question of designing the bore and stroke (eccentricity) for correct volumetric displacement necessary for requisite heat transfer will pose no problem to the manu facturer of the sealed compressor, provided that they are willing to part with a little extra profit, which accrue due to saving in material for a 2—Pole motor construction. The cost of labour involved in machining assembling or testing will hardly make any appreciable difference between 4- Pole and 2—Pole electric motors.

The sealed compressor being the heart and the costliest limb at that too, of a Room Conditioner, needs special attention for its protection and smooth operation. It is sustained by normal function of components like the relay, capacitors, correct refrigerant flow, and regular flow of air over the condenser coil fins and malfunction, singly or jointly may sound its death knell. The correct sequence of operation of the above is the responsibility of the service personnel.

There are two other enemies lurking around — low voltage or heavy voltage fluctuations and the moisture inside the system. Whereas the former has to be fought at the time of installation by means of suitable voltage stabiliser or correcting the electric wiring or by taking up with the appropriate supply Authorities, whichever is applicable, the latter namely the moisture, should be adequately fought on the shop floor at the time of assembly of the unit and which is squarely the responsibility of the manufacturer of Air Conditioner, requiring pointed attention.

Moisture in the system gets circulated all over, when the machine is running but a great portion of it settles on in the shell when stopped, affecting two vital parts namely the flapper valve and the windings. Corroded valves start working inefficiently and ultimately fail. Moisture settled on the windings, slowly start suphating copper wire at the weakest portion from which protective insulating enamel has either withered or weakened. This is a continuous process, without let or hindrance, going on round the clock, aggravated when the compress is stopped. It ultimately causes short circuit between turns or between the conductor and the "ground" with cumulative effect and one fine morning, the user learns to his dismay, that the sealed compressor is burnt out.

The moisture has to be driven out of the system before charging refrigerant by simultaneous heating and evacuation for several hours. Heating is limited by the temperature upto which the electric motor windings can stand and

both the winding wire and the lubricating oil may not deteriorate in their properties during the operation.

There are several ways of dehydration, some of which are very elaborate to ensure the job. The simplest but, nonetheless effective, is to evacuate the system for several hours inside a baking chamber heated upto 190 — 200°F and then closing the valve, and taking it out, it is allowed to cool down to the ambient (say 100°F at that moment). The system is again connected to a two stage fine vacuum pump, gauge connected and the pump operated. As 50 Micron Vacuum is reached, the system valve is closed and after some time, observation is made to find if there is any pressure rise. If there is no rise, the system is quite dry for charging. If there is rise, say to 100 Micron, the system should be dried further, because when the valve is closed and if there is some appreciable moisture, it would create its own pressure after the equilibrium is reached.

Certain physical facts need be emphasised in this connection to clarify the point. At 100°F fully saturated water vapour exerts 49062.6 Micron pressure and it contains 19.95 grains of water vapour per cubic feet of air, 50 Micron pressure is 0.102 % of fully saturated vapour pressure. The same evacuation at 95°F would exert 0.119 % of fully saturated vapour pressure.

If the ambient drops down as during the winter months, the system may be lightly warmed up within 95 — 100°F by extraneous means and fine vacuum drawn upto 50 Micron, as stated above, to ensure uniformity — because 50 Micron vapour pressure when evacuated at say 70°F would mean 0.226 % of fully saturated vapour pressure.

There are means of measuring the exact quantity of moisture drawn out, and the quantity left in the system, may be directly obtained by a little calculation.

Suppose that a system of 0.8 cubic feet is filled up with air at 100°F and 60 % relatlve humidity. It would contain 9.57 grain of water. If the dessicant absorbs 5 grains the balance is 4.57 grain. The prerequisites are three, volume content of the system, the temperature and humidity of air with which it is filled up and the gain in the weight of the dessicant. This provides added confidence in the method of final evacuation adopted.

HEAT LOAD

In Air Conditioning, heat is as much a load, as the feed and speed of a Lathe or Milllng Machine or capacity of water pump on the drive (say electric motor), a fact often not given due emphasis, which is regretable but true.

Before going into other aspects, heat load can be tangibly demonstrated in this way.

A simple experiment would prove the point beyond doubt. Connect an Ammeter into the circuit of a working Air Conditioner and note the reading. Reach the rear side (condenser side) and by some suitable arrangement, of say Card Board ducting, divert a portion of the hot discharge air into the side louvres through which some hot air would be sucked in. Within minutes the Ammeter reading would go on rising, indicating higher load. This proves that air at a higher temperature entering condenser side louvres increases heat load, as reflected directly by the ammeter readings. This experiment must not be continued for long for obvious reasons.

The main functions of the Air Conditioner is regulated heat transfer. When the unit is in operation, the room heat is lost through the Evaporator Coil and the room cools down. On the other end, heat is gained by the condenser coil and air blowing over its fins gets heated up, which can be directly felt. The cooler air in circulation inside the room has no direct contact with air in and out of the condenser. The actual heat transfer, that occurs, is through the cycle flow of refrigerant (RI2 or R22) inside the system. This transfer is essential.

Yet there is another heat transfer into the cool room inside, through the walls and windows and often roof, from outside, which causes a drop in the efficiency of cooling. Whereas, this process cannot be totally stopped, efforts should be made to minimise it, or in other words, for better cooling, the room should be heat-insulated, wherever economically feasible.

The principle, as explained, about the necessary heat transfer in the system itself and undesirable heat transfer through the walls and windows etc. is universally applicable to all types of Air Conditioners, whether central, package or unit conditioner, with the only difference, that in the other two, the condenser is water cooled.

If it were possible to cut out these unwanted heat transfer from outside into inside, comparatively smaller size of an Air Conditioner would be able to cool a largish room, but in actual practice, it is not fully achievable, due to the reason, that certain quantity of heat will sip into the room from all over and continuously, increasing the conditioned room temperature.

The dimensions and the construction of the conditioned room has a bearing upon the tonnage of Air Conditioner required, because larger room would present larger surface area of walls and ceilings through which heat would travel and yet these should not be the only criteria.

In order that the idea is fully grasped, it would be

helpful to know some of the salient factors.

(a) Higher the ambient temperature, greater the quantity of heat, that would diffuse through doors windows and walls and it would be directly proportional to the difference in the room and outside temperatures, for any particular room.

(b) Windows, walls and ceiling exposed to outside atmosphere will admit greater quantity of heat than those ones which are not so exposed.

(c) Very little heat from the ground would enter into the room on the ground floor. It may be neglected for the purpose of calculation of heat load.

(d) A non air-conditioned ground floor room would press some heat into the first floor air conditioned room through its ceiling.

(e) If there is an air conditioned room below practically no heat would enter into this air conditionep room through its floor.

(f) Heat enters into the room through a glass window exposed to atmosphere by radiation, which can be substantially curtailed by shutters or thick curtain.

(g) For a given wall, heat transfer is directly proportional to the difference between outside and inside temperature and inversely proportional to the wall thickness.

(h) Other things remaining the same, heat transfer would vary with the material used.

(i) Any living person emit heat, which varies to some extent from person to person, but appreciably for a person, depending upon what exactly he is doing, the minimum during sleep and maximum during hard physical labour.

(j) Electrical equipments like bulb, tube light, motors and of course heater emit heat. Needless to say, that a gas burner would emit heat.

(k) To cool room air, both sensible and latent heat have to be extracted. Sensible heat is felt but latent is not, but none-the-less, the latter has to be extracted to bring down the temperature.

(l) The same ambient but higher relative humidity, causes drop in cooling by the air conditioner, because it has to cool down the air together with extra water vapour in it. Moreover higher humidity causes a drop in the evaporative cooling of the surface of the condenser thereby lowering the efficiency of the air conditioner itself. The difference in wet bulb readings of air on and air off the Evaporator coil in a working air conditioner is indicative of its performance of heat transfer, when the ambient is constant.

The most sensible way calculating heat load for room office or a hall is to assume certain basic data of the performance or the job the air conditioner is called upon to perform under certain outside ambient conditions and then start calculating the losses, which in other words, means heat gained into the room from outside, which tend to raise the temperature of the conditioned room inside. If we know the temperature inside the room, the temperature obtaining outside and the room characteristics in details, we may easily calculate total heat being gained per hour either in B. T. U. or Kilo Calories and from which obtain the temperature rise in the room itself, its cubic content remaining constant.

In air conditioning, equilibrium of heat gained inside the room and heat lost, should be maintained for the required ideal condition. We may consider the following example.

Ambient of Lucknow on a day is 105°F D. B. & 55% R. H. Required Room Condition 82°F D. B. 50% R. H.

There would be certain amount of heat creeping into the room through walls and windows and may also creep in through ceiling or floor depending upon its situation. It would be necessary to break up the value of B. T. U. 's through each of the above sections and add them up, just the same way, as total expenses are arrived at by addition of individual item of expenditure.

It is necessary to emphasise that heat load calculation, on the whole, cannot be as precise as Arithmetical accuracy or even as grinding tolerance of a two inch steel rod, which can easily attain $\pm$ .025 % of the diameter, nor is it necessary for practical application in air conditioning. It has been noticed that some indenting authorities in their over-zealousness or through ignorance, specify some very close tolerances for temperature and humidity, which is not strictly necessary and which an ordinary air conditioner just cannot maintain. To satisfy these conditions, far more elaborate arrangement is required, which may be justified in some process control in the industry, but certainly not for human comfort.

Table IV gives ready values for different conditions. Only the surface areas (and not the volume of the entire room) of walls, windows, floors and ceilings should be calculated by actual measurement. The factors are multiplying factors bearing upon location, the material of construction and the thickness. The walls which do not face the open atmosphere, are partition walls and windows situated on these walls would have practically the same factor as the material of the partition if curtained. The factors for windows are those which are exposed.

In case of calculation of heat load in the southern Hemisphere is necessary, as in Australia or South America, situated on the South of equator, North and South factors, are to be reversed for geographical reasons, basic factors of temperatures, as assumed, remaining the same.

The total of each in the final column would give a fairly correct indication of heat load and from which tonnage of Refrigeration can be arrived at.

Table I records the total heat in B. T. U. (combined latent and sensible) in respect of Wet Bulb temperature within half degree of Fahrenheit variation to facilitate more accurate calculation. It is well known that in calculating heat load, the method of considering the total heat at certain Wet Bulb temperature, tallies favourably with broken up figures of each of dry air, water vapour, condensation of water vapour on reaching dew point, cooling this water and finally cooling the condensate, summed up together. Therefore, heat transfer represented in B. T. U. per hour based on enthalpy and total heat at Wet Bulb gives an indication of the capacity of the Air Conditioner, provided that the room is well insulated, though certain amount of leak would always occur, depending upon the volume of the room and the surface area it would present.

Enthalpic test may be adopted as a measure of routine test for Air Conditioners and allied products, though unsuitable for Refrigerators and water coolers.

In Table 111, reference to psychrometric chart is avoided entirely. The volume at zero percentage of Relative humidity is given along with the factor by which the actual percentage of R. H. is to be multiplied and added to the parent figure.

A worked out example at the bottom would clarify the issue. The accuracy not obtainable from psychrometric chart can be obtained by reference to Tables I & II, though there is some fallacy from strictly pure mathematical point of view, but it still has a positive advantage and it is expected that test room Inspectors would find it attractive and useful.

Recording thermometers are generally calibrated in centrigrade scale and table II would be handy in converting it into Fahrenheit scale and with the assistance of the foot note figure, the first place of decimal centrigrade can be thus converted. On the Fahrenheit side nearest half degree may be reckoned for total heat at wet-Bulb calculations as given in table III.

It is a matter of regret that manufacturers in India are so much obsessed with enthalpy that they do not consider the actual calorimetry which is just not so complicated as

one imagines. Probably taking cue from manufacturers, the Indian Standard Institute, does not insist upon actual calorimetric test and is quite satisfied with enthalpy. It does not require any stretch of imagination to say that calorimetric test gives far more accurate reading of heat transfer than enthalpy.

With good degree of sophistication already achieved in India, it is not difficult to fabricate a suitable calorimeter for this purpose.

The basic ingredients are electroplated copper container. insulating material like glass wool (cork may be discarded for its present day high price) recording thermometers, suitable stirrers, finned insulated air flow ducts, heating and cooling and humidifications at the condenser side, and the liquid may be brine or kerosine oil. To minimise the problem of heat transfer and consequent heat insulation, the calorimeter could easily be housed in a thermostatically controlled Air Conditioned chamber, which any manufacturer can provide for.

Calorimetric readings would give far more accurate heat transfer or B, T. U. per hour figure than enthalpy. Once, the exact capacity is determined, much more dependable data would be available for research and development on a commercial basis to economise on costly copper pipes and Aluminium fins, without jeopardising the efficiency of performance.

At the present moment, manufacturers are almost reluctant to tinker with the surface area of fins due to uncertainty. There is thus a very wide field for this type of applied research in India, where the manufacturers can achieve the dual objective of economy and the confidence in the product. This is applicable to Refrigerators as well.

It must be remembered that if we desire to export refrigeration equipment abroad against very stiff international competition, we should not be complacent about the cost of manufacture, process and procedure, which is generally based on borrowed technology, very many years old.

The author would be gratified if some manufacturers feel the necessity and the comparative ease with which a calorimeter for this purpose can be fabricated, which in the final analysis would be in the national interest.

Table 1

Total heat of air in relation to Wet Bulb temperature in Fahrenheit.

Wet Bulb °F	Total heat per lb of dry air (Sensible & Latent) B. T. U.	Wet Bulb °F	Total heat per lb of dry air (Sensible & Latent) B. T. U.
35	12.979	45.5	17.815
35.5	13.194	46	18.120
36	13.409	46.5	18.380
36.5	13.627	47	18.64
37	13.845	47.5	18.900
37.5	14.065	48	19.16
38	14.285	48.5	19.430
38.5	14.511	49	19.70
39	14.736	49.5	19.975
39.5	14.964	50	20.25
40	15.191	50.5	20.525
40.5	15.424	51	20.80
41	15.657	51.5	21.090
41.5	15.894	52	21.38
42	16.130	52.5	21.665
42.5	16.375	53	21.95
43	16.620	53.5	22.25
43.5	16.865	54	22.55
44	17.110	54.5	22.85
44.5	17.360	55	23.15
45	17.610	55.5	23.46

Contd.

Table 1 (Contd.)

Total Heat of Air in relation to Wet Bulb temperature in Fahrenheit

Wet Bulb °F	Total heat per lb of dry air (Sensible & Latent) B. T. U.	Wet Bulb °F	Total heat per lb of dry air (Sensible & Latent) B. T. U-
56	23.77	66.5	31.12
56.5	24.085	67	31.51
57	24.40	67.5	31.91
57.5	24.725	68	32.31
58	25.05	68.5	32.715
58.5	25.375	69	33.12
59	25.70	69.5	33.54
59.5	26.035	70	33.96
60	26.37	70.5	34.395
60.5	26.715	71	34.83
61	27.06	71.5	35.265
61.5	27.41	72	35.70
62	27.76	72.5	36.15
62.5	28.12	73	36.60
63	28.48	73.5	37.055
63.5	28.845	74	37.51
64	29.21	74.5	37.985
64.5	29.585	75	38.46
65	29.96	75.5	38.94
65.5	30.345	76	39.42
66	30.73	76.5	39.91

Contd.

Table 1 (Contd.)

Total heat of air in relation to Wet Bulb temperature in Fahrenheit.

Wet Bulb °F	Total heat per lb of dry air (Sensible & Latent) B. T. U.	Wet Bulb °F	Total heat per lb of dry air (Sensible & Latent) B. T. U.
77	40.40	87.5	52.38
77.5	40.91	88	53.02
78	41.42	88.5	53.685
78.5	41.94	89	54.35
79	42.46	89.5	55.025
79.5	42.985	90	55.70
80	43.51	90.5	56.395
80.5	44.06	91	57.09
81	44.61	91.5	57.805
81.5	45.165	92	58.12
82	45.72	92.5	59.255
82.5	46.30	93	59.99
83	46.88	93.5	60.745
83.5	47.465	94	61.50
84	8.05	94.5	62.275
84.5	48.645	95	63.05
85	49.24	95.5	63.835
85.5	49.855	96	64.62
86	50.47	96.5	65.435
86.5	51.105	97	66.25
87	51.74	97.5	67.085

Contd.

Table 1 (Contd.)

Total Heat of Air in relation to Wet Bulb temperature in Fahrenheit

Wet Bulb °F	Total heat per lb of dry air (Sensible & Latent) B. T. U.	Wet Bulb °F	Total heat per lb of dry air (Sensible & Latent) B. T. U.
98	67.92	101.5	74.135
98.5	68.78	102	75.06
99	69.63	102.5	76.015
99.5	70.515	103	76.97
100	71.40	103.5	77.945
100.5	72.305	104	78.92
101	73.21		

Table II

Conversion from Centigrade Readings to Fahrenheit temperature.

C	F	C	F
– 40	—40	20	68.0
—30	—22	21	69.8
—20	—4	22	71.6
—10	14	23	73.4
0	32	24	75.2
1	33.8	25	77.0
2	35.6	26	78.8
3	37.4	27	80.6
4	39.2	28	82.4
5	41.0	29	84.2
6	42.8	30	86.0
7	44.6	31	87.8
8	46.4	32	89.6
9	48.2	33	91.4
10	50.0	34	93.2
11	51.8	35	95.0
12	53.6	36	96.8
13	55.4	37	98.6
14	57.2	38	100.4
15	59.0	39	102.2
16	60.8	40	104.0
17	62.6	41	105.8
18	64.4	42	107.6
19	66.2	43	109.4

Contd.

Table II (Contd.)

Conversion from Centigrade Readings to Fahrenheit temperature.

C	F	C	F
44	111.2	68	154.4
45	113.0	69	156.2
46	114.8	70	158.0
47	116.6	71	159.8
48	118.4	72	161.6
49	120.2	73	163.4
50	122.0	74	165.2
51	123.8	75	167.0
52	125.6	76	168.8
53	127.4	77	170.6
54	129.2	78	172.4
55	131.0	79	174.2
56	132.8	80	176.0
57	134.6	81	177.8
58	136.4	82	179.6
59	138.2	83	181.4
60	140.0	84	183.2
61	141.8	85	185.0
62	143.6	86	186.8
63	145.4	87	188.6
64	147.2	88	190.4
65	149	89	192.2
66	150.8	90	194.0
67	152.6		

N.B. 0.1°C = 0.18°F

Table III

Volume of dry Air in cubic feet per lb at 29.92 inch Mercury pressure & corresponding increase with rise in percent of relative Humidity.

Col I Dry Bulb °F	Col II Cft per lb of Air at 0% R.H.	Col III Multiply this factor by % R.H. & add to Col II
40	12.59	.0010
41	12.61	.0011
42	12.64	.0011
43	12.66	.0012
44	12.69	.0012
45	12.71	.0013
46	12.74	.0013
47	12.76	.0014
48	12.79	.0014
49	12.81	.0015
50	12.84	.0015
51	12.86	.0016
52	12.89	.0017
53	12.91	.0018
54	12.94	.0018
55	12.96	.0019
56	12.99	.0020
57	13.01	.0021
58	13.04	.0021
59	13.06	.0023
60	13.09	.0023
61	13.11	.0024
62	13.14	.0025
63	13.16	.0026
64	13.19	.0027

Contd.

Table III (Contd.)

Volume of dry Air in cubic feet per lb at 29.92 inch Mercury pressure & corresponding increase with rise in percent of relative Humidity.

Col I Dry Bulb °F	Col II Cft per lb of Air at 0% R.H.	Col III Multiply this factor by % R.H. & add to Col II
65	13.21	.0028
66	13.24	.0029
67	13.26	.0031
68	13.29	.0031
69	13.31	.0033
70	13.34	.0034
71	13.37	.0034
72	13.40	.0035
73	13.42	.0037
74	13.44	.0039
75	13.47	.0040
76	13.49	.0042
77	13.52	.0043
78	13.54	.0045
79	13.57	.0046
80	13.59	.0049
81	13.62	.0050
82	13.64	.0052
83	13.67	.0054
84	13.69	.0057
85	13.72	.0058
86	13.74	.0060
87	13.77	.0062
88	13.79	.0065
89	13.82	.0066
90	13.84	.0069

The volume of air (say in cubic feet per pound) at constant atmospheric pressure, increases with moisture content in it, because the fine particles of water suspended in air exerts pressure, called vapour pressure.

At Dry Bulb Temperature 100°F and Relative Humidity of 100% (i. e., Wet Bulb 100°F) vapour pressure is 1.9316 inches of mercury or 0.9487 pounds per square inch.

To work out the volume per pound of air from the table the following example would clarify the issue :

Example : Dry Bulb 50°F, Relative humidity 40%, find out the volume in cubic feet per pound at atmospheric pressure. At 50°F, R. H. 0%, volume is 12.84 CFt. (From Table) Factor .0015 X 40 = .06

12.84 + .06 = 12.90 CFt. per pound.

From the table fairly accurate volume and weight relationship between 40°—90°F and R. H. 0—100% can be obtained. The range 40° to 90°F has been chosen as the conditioned temperature would lie within this limit.

Note : In calculating the total heat of air in relation to ½° F changes, it has been reasonably assumed that in a parabolic curve, small differential in co-ordinates, is almost linear in variation and similar procedure is adopted for enthalpy table. It is expected that this ready reckoning would facilitate heat load calculation, though for **B. T. U.** yield from an Air Conditioner, actual calorimetric test, is by far the superior method as stated elsewhere.

Table IV

Ready Reckoner

Heat Load for Residential & Office Application only.
(Comfort Cooling)

Basic Data : Outside 104°F (DB) 60 % R. H.

Attainable Room Conditions 80°F D. B. 67°F W. B.

Name and address of the user : ....

or/and place of application ....

Effective conditioned space : Length X Width X Height = Vol. Cft.

Room characteristic (Conditioned space)

Exterior walls facing	Height	Width	Area Sq.ft.	8 Inch Factor	8-16 Inch Factor	Above 16 Inch Factor	B. T. U.
North				5.1	4	3	
N. E.				8.3	4	3	
East				9.2	6	4	

Contd.

Table IV (Contd.)

Ceiling	Length	Width	Area Sq. ft.	Factor	B. T. U.
Concrete (not exposed)				13	
Concrete (exposed)				35	
Concrete & False (not exposed)				5	
Concrete & False (exposed)				20	

Floor	Length	Width	Area Sq. ft.	Factor
G.F or Floor above airconditioned room				0
Floor above another room				13

Electricals	No.	Watts	Total Wattage	Factor
Light (Bulb)				3.8
Light (Tube)				3.0
Appliances				3.5

Contd.

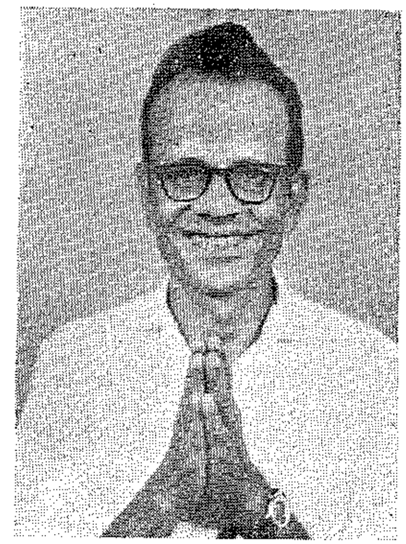
Table IV (Contd.)

Electricals	No.	Watts	Total Wattage	Factor	B. T. U.
Heater				4.2	
Gas burner (domestic)	No.			1000 each	
Room occupants	No.			525 each	
Casual visitor	No.			650 each	
Fresh Air				61 per Cfm.	
			Grand Total (B.T.U.)		

INSTRUCTIONS :—

1. (a) For obtaining B.T.U. in each column multiply either Area or Total wattage by corresponding Factor, as the case may be and then add up.
   (b) For persons and burners multiply the total No. by the Factor and add up.
2. Better draw a line sketch of the room indicating the sizes, position (N.S.E.W.) and location of doors, windows and partitions, as a check and for records.
3. Special application has to be evaluated Separately.

The author thanks you for the interest you have taken to conclude reading of this book. Your comments and suggestions would be welcome to the publisher for more detailed and varied publication in future on these matters.



(Namaste from author)

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