Dedicated to my father, Late Harendra Narayan Sinha, an unfailing source of inspiration.

AIR CONDITIONING & AIR CONDITIONERS

(in correct perspective)

The author's humble attempt to share knowledge of his experience, acquired during the two decades of practice, in an objective way.

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Contents

Foreword

During my long practice in Air Conditioning, covering two decades in India, I have come across quite a lot of confused thinking and vague ideas, may be common in other parts of the globe as well, which do not stand scientific or technological scrutiny, even from otherwise educated persons, and which need be cleared, not only in the interest of the manufacturers and suppliers of the equipments, but also in the interest of customers themselves, to create enlightened opinion and healthy criticism, essential for better production, development and service.

To quote an example, I may refer to the confrontation I had with a Works Engineer of a firm of repute who complained about less cooling of an Air Conditioner with the argument that "irrespective of the Ambient temperature and Relative humidity obtaining outside, a good Air Conditioner should be capable of bringing down the conditioned room temperature to 60°F, no matter, even if outside is 114°F, just as a 10 H. P. motor would develop 10 B. H. P., independent of the load to which it is coupled".

I made persistent but futile attempts to convince him that one Ton Air Conditioner can only effect a transfer of

12000 British Thermal Units or roughly 3000 Kilo-Calories per hour and it would do so, though with varying outside conditions of temperature and humidity, the inside conditions may vary, without jeopardising the output expressed in B. T. U. per hour, except to a marginal value. He remained thoroughly unconvinced, detriment to the goodwill of the brand of Air Conditioner installed in his works office, which he said was poor in performance and need be returned,

I am not aware whether he had been told similar reasoning by other person from a different firm or he had ever been convinced.

This is only a typical case and scores of such examples may be quoted. This small book is intended to remove some of the misconception prevalent and also serve as guide lines for specialists in the subject for further research and development, which my experience has forced upon me to express in an objective way.

Table I has been prepared with a view to determine total of sensible and latent heat in respect of Wet Bulb Temperatures drawn within half degree of Fahrenheit, Table 11 as a ready Reckoner for conversion of Centigrade to Fahrenheit as the recording thermometers generally read in Centigrade Scale. Table I11 would help calculation of weight of air in relation to volume at any temperature

and relative humidity very accurately, without reference to psychrometric chart which in many cases cause fatigue to eyes without ensuring this much accuracy. An example given at the end of the table is intended to clarify the procedure.

At the foot note explanation is provided as to the way the figures are arrived at, which though may be questioned from pure mathematical point of view, would be readily acceptable to Engineers for practical application without hesitation.

The fundamental principles involved in Air Conditioning (and also Refrigeration) is simple and would be clear to anybody having good grasp of physics, specially chapters on HEAT, ENTHALPY, PSYCHROMETRY, CALORIMETRY etc. For details of working of modern Air Conditioners, knowledge of drive, reciprocating and rotary movement of Compressors, fluid movement, electrical components and their circuits, vapour pressure of fluids, critical temperature for liquefaction under pressure, surface transfer of heat etc. would be necessary, and these are beyond the scope of this book and are assumed from specialists. Nevertheless, even by skipping over this knowledge, there is enough material for an intelligent person or a man associated with this trade, which would presumably be interesting. Practical experience has been given prece-

dence over multitude of books, published abroad for reference.

In this context, the author desires to express the opinion that an Engineer, who spends two thirds of his working life in one branch of engineering, has something to offer original in presentation if not in thought, if he cares and the author would consider his labour amply justified if this write up can stimulate thought and action in the matter by other fellow Engineers or people concerned.

The author expresses his sense of gratitude to Shri Tarun K. Mukherjee for his contribution to the growth of customer-oriented attitude for objectivity and to Shri Arun Kiran Basu for his untiring effort, without which the publication would have been very much delayed.

Calcutta, D. N. Sinha.
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Background

Air Conditioning in India made its appearance in a small beginning. A few firms took out agencies of British and American manufacturers for selling, installation and service of air conditioning plants and equipments during the decade preceeding the Great War with practically no manufacture of any component in India. These firms only sold the self contained units and assembled the central Air Conditioning plants, installed and serviced them. Naturally foreign nationals predominated.

Today it is a very significant industry occupying a pride place in sophistication, substantial in investment, remarkable in employment potential and properly nurtured, would grow in dimensions, to look forward to future with full confidence. In the field of room conditioners almost the entire components are fabricated in India with Indian material though "know how" has been borrowed through collaboration in certain fields like compressor manufacture, probably more through expediency than sheer necessity.

For central Air-Conditioning, components are increasingly being manufactured in India and the protection offered by the Government of India is a valuable incentive in this direction. In the field of Industrial Fans and Control and movement of air flow, the country is self-sufficient.

Side by side with technological advance, diffusion of knowledge of actual working, the limitations etc. should be brought into correct perspective, otherwise, unduly high expectations may be raised, which cannot be achieved and need not be achieved either. It is universally applicable to all countries and all items of manufacture. Public relation through sales personnel of different firms exists, but, not being objective, it suffers from a pronounced handicap, which is easily visualised. Moreover, such personnel having an axe to grind, are sometimes, not above reproach.

Function :

An Air Conditioning device, from small room conditioners to large central plants, need do the following, rightly expected of it.

(a) Comfort cooling (including partial dehumidification) irrespective of outdoor climatic conditions.

(b) Removal of dirt and dust in circulation in air and incidentally making the air infectious germ-free to an extent,

(c) Removal of stale or smoke laden air from inside at will.

(d) Maintenance of correct oxygen content in the room to prevent heavy breathing by inmates.

As item (a) requires somewhat elaborate treatment, it would be dealt with last.

Dirt and Dust

A built-in filter in case of smaller units and quite a number of them placed in the return air chamber of central Air Conditioning plants, collect dust from the air circulated and recirculated by the blower fan through these filters silently and efficiently. They are washable and cleanable and can be used for a long time.

Though infectious germ-free operation cannot be guaranteed and should not attract implicit faith in it, nevertheless application of some detergents or pesticide on the filter surface exterminate germs. Sweet scent added to filter would lend fragrance inside the room.

Stale air

A lever arrangement, manually operated or relay operated, actuates exhaust operations and stale air is driven out of the room. In the central plant the blower fan is run with all doors and windows open and the room air is flushed.

Fresh air

Just as the stale air is flushed by operating a lever,

fresh air is drawn in by another movement. It is simple and effective. With occupants residing inside the room oxygen content goes on reducing unless replenished. Some discriminating customers and therefore some manufacturers, prefer continuous automatic flow of fresh air rather than by sporadic lever movement, which has to be made at certain intervals. In applications as at hotels and guest-houses this is preferred and also in the household where the occupants do not wish to be bothered without being inconvenienced. In case of continuous flow of fresh air, the manufacturers should specify the quantity of heat to be gained by this process and should not normally exceed 8 percent of the total B. T. U. yield. It should be noted that in selective fresh air control the B. T. U. per hour yield is also diminished as long as fresh air is open.

Comfort cooling.

It is related to the comfort of man, who inhabits the globe in the widest area under most varying climatic conditions. No other animal probably can stand and thrive under such extreme conditions. In certain regions of California maximum shade temperature is known to shoot beyond 130°F and in areas of Rajasthan 125°F during peak summer has been recorded, against —85°F reached in northern Siberia during the coldest season. The difference between the global highest and lowest is thus 215°F.

Ice need be raised to additional 180°F to melt and boil. Yet man lives under these extremes. As the temperature, so the humidity varies greatly from 0.0017 grains per cubic feet of air in Siberia and upto 20 grains per cubic feet of air on tropical seashore places. For human comfort or discomfort, temperature, though playing a significant part is not the sole factor. An example near at home would bring the point out.

A man from Delhi, quite accustomed to a summer temperature of 104°F, would generally feel extreme discomfort in Calcutta on a day in August with only 99°F temperature. There is no mistake about the temperature mentioned nor there is any doubt about the sense of discomfort. The factor responsible for the feeling of uneasiness is the moisture content in the air obtaining in Delhi and Calcutta. Whereas, on a dry April day Delhi with 104°F Dry Bulb temperature, may have relative humidity of 30 percent, corresponding to 6.7 grains of water vapour per cubic feet of air, against Calcutta 99°F Dry Bulb temperature, 90 percent relative humidity corresponding to 17.45 grains per cubic feet.

It will therefore be apparent, that Calcutta having a temperature advantage of 5°F (104—99) for human comfort, on the whole is uncomfortable due to presence of extra water vapour of 10.75 (17.45—6.7) grains per cubic

feet of air. These tiny invisible particles 10.75 grains in one cubic feet make all the difference to the man from Delhi.

On the contrary, I have known a Rajasthani who feels Calcutta weather in April quite agreeable with its lower temperature but higher humidity than obtaining in his place of original residence where, temperature is higher and humidity is lower during the period, because somewhat higher humidity is soothing to him than bone dry heat.

Human body is a very complex mechanism which maintains the body temperature constant, independent of atmospheric temperature. Higher atmospheric temperature induces perspiration in the form of water, which, when readily absorbed in the air at lower relative humidity, causes less irritation than when it wets the clothes at a higher relative humidity of surrounding air, because under the latter condition, air has limited capacity to mop up water coming out of body.

A very common experience, must have been shared by many people living in cities near seashore within tropics, is that on a hot humid day, the ceiling fan above head running at full speed does not provide any relief, because hot atmosphere causes body to sweat, which cannot dry up by absorption into the air, being near saturation point

or its capacity to take further water vapour is very limited. If it were possible to curtail humidity of air at that situation, the ceiling fan would provide instant relief.

To achieve comfort cooling, temperature should be brought down along with water vapour in the air. This is achieved by the Air Conditioner. The discharge air from the unit is blown into the room, gets circulated and mixed with room air and finally sucked back into the Air Conditioner itself. This is a continuous and repititive process and remains in operation as long as the conditioner runs. The return air enters into the plenum chamber, through air filter, gets cooled in the chamber and comes out. As the air cools so does the moisture in it, which on reaching dew point, unloads part of its water vapour and comes out drier than before or in other words relative humidity of the conditioned air is diminished. Dehumidification is accelerated when the relative humidity is high. Condensed water from the evaporator coil is drained out towards the condenser coil for utilisation as evaporative cooling of this coil, which helps increase in the efficiency of performance of the machine.

Ideal comfort

Ideal comfort is achieved by the "effective

temperature," which is somewhat arbitrary, though based on the joint effect of Dry and Wet Bulb temperatures of air in circulation upon human body. There has been quite a lot of discussion by many learned and distinguished members of the profession on the subject and most of them agree that ± 3°F of the effective temperature is still comfortable, ± 6°F is well tolerated and ± 9°F uncomfortable. The American Society of Heating and Ventilation Engineers' findings are :—

Basis :— effective temperature for ideal comfort,

+ 3°F Comfortably warm	— 3°F Comfortably cool
+ 6°F Quite warm	— 6°F Quite cool
+ 9°F Hot	— 9°F Cold

Unfortunately, all are not agreed on what the effective temperature should be for a particular location. The problem is more biological than physical and should be tackled as such. In India some original research work should be undertaken for different regions jointly by the biologists and physical scientist in collaboration with Meteorological Departments and Observatories. However, two things are reasonably certain, that is, the effective temperature should be based on the joint effect of humidity and temperature and also that it has definite relationship

with the geographical latitude of the place concerned.

The London School of Tropical Medicine upon a detailed survey and investigation recommended 85°F D. B. and 72°F W. B. for ENUGU in Nigeria, which is generally accepted as authentic. The effective temperature for these readings is worked as 78.2°F with air in circulation over person. Stagnant air would not give the same comfort.

The effective temperatures of major Indian cities widely dispersed are given in the following table.

City	Effective Temperature
Calcutta	75.4°F
Bombay	76.2 "
Madras	77.4 "
Delhi	74.4 "
Ahmedabad	76.5 "
Cuttack	76.1 "
Jubbulpore	75.6 "
Nagpur	75.8 "
Trivandrum	78.4 "
Hyderabad	76.6 "

For geographical locations with respect to Latitude.

Latitude	Effective Temperatures *
5	79°F
10	78 "
15	77 "
20	76 "
25	75 "
30	74 "
35	73 "
40	72 "
45	71 "
50	70 "

* + 3°F above would remain comfortable.

The above figures need not be taken too literally because, though the avevage person would feel comfort, idiosyncracies cannot altogether be overlooked. Moreover, authentic research to suit Indian temperament, as already suggested is meagre. The object of emphasising upon research in Indian conditions is in no measure to trifle with the valuable work done abroad, but for the

potentiality of opening up new horizon yet in the dark.

Dehumidification

The principle of dehumidification in general has already becn touched upon previously. In Air Conditioner no special device need be provided for comfort as a must, as it is inherent in the process itself, though in a limited way, yet nonetheless effective for comfortable feeling. If the relative humidity is required to be rigidly adhered to for any specialised application, say process control, the room Air Conditioner would hardly be able to do justice to temperature and humidity control conjointly. It would do two together reasonably well as explained, for human comfort.

In a room Air Conditioner say of 1.5 Tonnage Refrigeration, the rate of condensation would be reasonably satisfactory if it reaches a maximum value of 4.5 litres per hour at 70% relative humidity. The values for I Ton (R) and 2 Ton (R) would be correspondingly lower and higher than this. As there is no extra equipment only two things need be attended to for proper condensation— the filter clean and Evaporator fins not clogged. Under these conditions, condensation would work uninterruptedly for a long time.

For control of humidity alone, more effective and economical means are available to Engineers.

In certain applications, particularly suited to central Air Conditioning plants, dehumidification is emphasised. The control room of a central power station, Automatic Telephone Exchanges, Transmitting stations or Radar rooms must not have a relative humidity higher than 50 percent, otherwise some very sensitive relays either deteriorate or there is loss of efficiency.

Dehumidification is achieved by placing suitably designed strip heaters in the air stream, which is actuated by HUMIDISTAT or DEW-CELL for maintaining the correct level. It works very well for central plant but in a room Air Conditioner it is not quite suitable for the reason that it is a negative process. With limited capacity to cool, it has not many B. T. U. 's to spare to warm up the air for reduction of humidity.

Noise :

Noise like ideal comfort temperature is again a question of senses. Men put up with certain noise without murmur as travelling in a plane, train, tram, bus and street noise etc., of course out of sheer compulsion of it, but rightly resent undue Air Conditioner noise because it is situated in home or office, unlike transport vehicle or workshop

machine like Lathe drilling machine or shaper from which noise is expected and tolerated.

It is very hard to define accurately and harder still to pin point the limit of acceptability by different persons, as in the final analysis it is psychological in nature. In the physical sense, it depends upon frequency and amplitude of vibration.

In an Air Conditioner it is sometimes very loosely talked about. Some manufacturers claim "Whisper-silent" operation, which is just a tall exaggeration, for the simple reason, that a reciprocating compressor working together with a motor driving two fans, situated upon a compact sheet metal tray, would create noise inside the room, which is not possible to be reduced to such a low level. Two types are associated with Air Conditioners — surface vibration and air generated and airborne noise.

The sheet metal components like bottom tray, cabinet, having a large surface are set into vibration. Propellers and Impellers vibrate due to movement and air over coil fins and through the air duct cause all these to vibrate and its own turbulence mingle with it, the splashing of condensate water in the tray adds to it. All these vibrations modulate and the resultant product, is the noise from the Air Conditioner.

The method of measurement and interpretation of

noise, as is generally adopted, is exposed to valid criticism. The practice is to hold a netted spherical knob of the meter at a distance of about 3 feet on level with the mid point of the column of streaming air and record the total decibel emanating from the Air Conditioner in operation. The spherical knob collects all frequencies with their amplitudes and the effect of resultant energy is measured. The overall effectual energy is correctly recorded, no doubt, but the identity of individual components of sound remains anonymous. Yet some of these singly or jointly together might be most annoying, though contributing the least to the total energy recorded as decibel. A child's shriek 25 feet away is more annoying than loud shout of an adult very much nearer. In effect, many cases have been observed wherein a customer, without being prejudiced, considers an Air Conditioner with higher decibel yield more silent than one with lower decibel yield.

It is no use being sceptical about this or that customer's notion about sound. He is quite right but let us admit our limited knowledge in this field. As has been pointed out elsewhere that valuable work has been done abroad by researchers in establishing relationship between the effective temperature and ideal comfort and the same amount of interest is called for in stratification of frequencies and amplitudes of vibration emanating from the Air Conditioner, in relation to reaction of human beings of different age groups, which would provide valuable information to manufacturers of Air Conditioners to isolate and eliminate those, as far as possible, ensuring more pleasant operating conditions. Analytical investigation on the above lines in an integrated approach is therefore urgently required.

However, till such time as detailed and reliable data are available it would be quite fair to state that the sum total energy recorded in the meter as sound, 52 to 54 decibel is satisfactory.

The problem of noise is far less pronounced in central Air Conditioning, where all moving parts are situated outside the buildings, except the air in circulation, which passes through suitably designed insulated ducts, often inside the false ceiling. Moreover, the linear speed of air flow from the duct through diffusers, inside the room is very much lower than that from unit Air Conditioners. Noise comparison between the two is therefore unfair in this context.

A reference may however be made to the Floor Model (often called Console Model) Air Conditioners remarkably silent in operation, the plenum and the condensing unit consisting of the compressor and the condenser were spaced very liberally apart, double panelling consisting of sheet metal below

padded wooden cabinet, resting on it together with spring mounted wooden grille, could dampen or absorb modulation making it much quieter. There were very few, if at all, noise complaints from the user, but due to economy in material and the floor space of rooms and offices, these have fallen in grace and are not marketed. Another contributory factor to noise of window Air Conditioners is enhancement of speed from 1450 R. P. M. to 2800 R. P. M. for material economy in compressor.

Now that the overwhelming majority of Air Conditioners run on A. C. and the most of them have Hermetically Sealed Compressor in them, objective analysis of the function of the component parts is worthwhile.

OVERLOAD Protectors.

Every sealed compressor is equipped with overload protector which is a bi-metal sheet strip construction and the idea is to prevent the motor windings from burning out on occurrence of abnormally high amperes. Expansion of sheet takes place due to heat or current or both and cuts out or breaks the contact connected in series with the circuit, when abnormally high current flows through it or otherwise becomes unduly heated up. On cooling of the strip, the contact is restored even without restoration

of normalcy in current. If the abnormal conditions persists, the protector will continue to cut in and cut out indefinitely and stator windings would burn. In fewer cases the fuse may blow, but normally it does not, because the fuse size is such as would stand the starting current, which is more than 3 times full load current.

It is a low cost equipment to give a warning signal, like a road sign warning the driver of the danger ahead, which is meant to be heeded, unmindfulness being perilous. During temporary cause, like drop in voltage for a couple of minutes, this protector works satisfactorily, but if the cause persists, it would go on cycling ON and OFF indefinitely, until somebody switches the Air Conditioner off and if there is nobody handy or the occupant of the room is ignorant or unmindful, the compressor motor would burn out. The factors causing high amperes are many — low voltage due to supply company's cable fault or fault in the house wiring or malfunction of the relay or the starting capacitor.

The overload protector used in the present form is therefore not fool-proof. A costly Air Conditioner, specially in the Indian Conditions, where the customer pays a sizeable sum in the price and taxes, maintenance and repairs, surely, deserves a better safeguard for preventable burn outs by more positive means, which are available in

plenty. The manufacturers of Air Conditioners in the U. S. A. may use this existing protector with some justification, comparative cheapness of Air Conditioners being one, though that may also be refuted.

Instead of Bi-metal protector, a circuit breaker, which should trip out at the predetermined flow of Ampere should be used and which would not restore the circuit of its own without somebody doing it. Not to speak of more advanced countries, such things are locally being manufactured in India, against which, the overload protector, upto this day, is imported. The price of the circuit breaker is some what higher, but not to the extent of being uneconomical for use in Air Conditioner. With its incorporation, the free service guarantee can be enhanced to three years, instead of the present practice of only one year in India. With a little care and thought in installation and maintenance and rigid inspection of the circuit breaker, the guarantee can be extended further.

The mounting is no problem either, the compact ones can be mounted behind the control panel of Air Conditioners and where it is installed at a height, this could be mounted on a Board near the electrical Power Socket.

It would not inconvenience the customer in case of temporary low voltage condition, he would restore the

circuit breaker and the machine would continue to run, and in case of prolonged low voltage, or fault in the relay or starting capacitor or the wiring, he would restore the circuit breaker twice, at the most three times, and then realising something amiss, he would not attempt further, and await arrival of a mechanic for skilled attention,

THERMOSTAT

It is a piece of mechanism, which controls and operates an electric circuit making and breaking with temperature variation as desired. The principle of operation is simple, the tail of the thermostat, usually located at the return air region over the filter, contains gas, which expands and contracts with the change in the temperature of air flowing over it, The varying pressure exerted by the gas is ultimately transmitted at the other end upon bellows spring, which in turn operates the mechanism ON & FF of the electrical contacts, connected in series with one of the lines, supplying electric power to the compressor.

It is reliable and works well for a long period, unless gas escapes through damage of the tail or the bulb or the bellows.

The limit of operation range is claimed to be generally 60°—90°F. But guaranteed operation at some definite

temperature cannot be assured.

A thermometer also works on the principle of expansion or contraction of Mercury or Alcohol or other gas and is quite accurate, expansion and contraction is directly read on the scale, whereas the expanded or contracted gas in the tail of the thermostat actuates the bellows spring. Therefore, a time lag or differential is bound to exist between cutting in and cutting out temperatures.

Moreover, no bellows spring can be so accurate as to respond and operate every time upon contraction of gas in the tail after an adjustment initially is made for say 72°F.

In plain language, say a thermostat is set to cut out at 72°F and cut in at 75°F may not be able to repeat the performance indefinitely in the sense, a thermometer would go on recording 72°F on occurrence of a particular expansion of mercury or alcohol contained in its bulb, without let or hindrance,

This need not cause alarm to the user, who can always set and reset the thermostat by a little turn of the knob clockwise or anti-clockwise to suit the temperature of his liking or requirement without much inconvenience or effort on his part.

It is precisely for this reason, that many manufacturers have discarded the practice of marking thermostat positions to the corresponding temperatures and where the

practice is in vogue, it should not be taken too literally.

RELAY

The effective function of the relay is transient in nature. It cuts out the starting capacitor within seconds of switching on the compressor and the action may be compared to the centrifugal switch of a single phase capacitor start motors, the rotors of which house the centrifugal mechanism.

From technical considerations, it is difficult to mount the centrifugal arrangement on the rotor of the sealed compressor and it has therefore to be extraneous. Generally, there are two capacitors in use for the motor portion of the sealed compressor, the starting capacitor gives a kick or boost or torque to the rotor in conjunction with the running capacitor and goes out of the circuit. The running capacitor remains on in the circuit in series both with start windings and potential coil of the relay to hold the other contact in abeyance by electro-magnetic pull. With switching off, the magnetic pull ceases and the contact springs back, bringing the start capacitor back into the circuit, and ready for another switching on. It is capable of numerous repitition.

If the ampere turn of the potential coil is judiciously

designed not to cause magnetic super saturation of the iron core and if the hyterisis and eddy current losses of the core itself are within limits, the potential coil should last for years. The spring should not of course be fatigued after many operations nor the electrical contacts burn out or get pitted on make and break even after 2000 operations.

P. S. C. & C. S. R. CONNECTIONS.

P. S. C. means Permanent Split Capacitor and C. S. R. Capacitor start and (Capacitor) Run.

The principles of these are not unknown to electrical Engineers, though application in the sealed compressors is comparatively of recent origin. The sealed Compressor motor has start (auxiliary) and Run (Main) windings, joined to a common point. In P. S. C. only the run capacitor is permanently connected in series with the "start" windings and remains on in the circuit, and the use of the relay and the start capacitors are dispensed with. It is decidedly cheaper and simpler in operation but, where the voltage falls below to generally about 190 V (standard being 230 V) this arrangement is incapable of starting the compressor, because with only one capacitor the

starting torque is less than 20 per cent of the dual capacitor. In certain cases where the alignment of moving parts is stiff, P. S. C. may even at 230v. fail to start. C. S. R. has one relay and two capacitors, one of which is cut out by the relay, after the start and the other stays on.

This may be compared to two persons start pushing a loaded stationary scooter van whose fuel is run out. With the effort of two it starts moving on the wheels, when one man gives up the job of pushing, leaving the other to take it down to the filling station. C. S. R. is recommended for chronic low voltage condition or stiffness in alignment inside, though additional start capacitor and the relay have to be paid for. Under such circumstances, in P. S. C., one man has to struggle on whether he is capable of moving the scooter van or not. If he cannot, he would be fatigued and would give it up, but one capacitor in P. S. C. would have to struggle, only leaning on the support of the overload protector to cut out, which in turn would go on cycling ON and OFF till probably, the Compressor motor windings becoming the first casualty.

It is of course possible to convert P. S. C. into C. S. R. without difficulty by additional Relay and the start capacitor.

The bigger the H. P. of the motor, more difficult it is

to start it on P. S. C. and it is generally unsuitable for 1.5 Tonnage of Refrigeration or higher ones.

In the packaged type of Air Conditioners ranging from 3 to 7.5 Tons. the problem of Selection of P. S. C. and C. S. R. is non-existent. The motor used to drive the sealed compressors in such units are 3 Phase A. C., which provides uniformly good starting torques without capacitors.

The limiting factor for the use of higher Horse Power motor on single Phase (230 volts 50 cycles in India) is the supply undertakings objection. In some cases, in India, Electric Supply Authorities are reluctant to sanction power connection for single phase lines to equipment using $2\frac{1}{2}$ H. P. motors for their own balancing problems. However, such objections are not raised if 3 Phase connection is taken in a building, the owner of which assures that proper balancing of electric load would be achieved at his end.

SELECTOR SWITCH

As the name itself implies its function is to selectively run the Air Conditioner for "fan only" and "cool". Fan only does not cool, fan and compressor together cools the room. The switch position should be such as to run in

the sequence ; under no circumstances the switch arrangement should be such as to run the compressor only, which would dangerously build up the discharge pressure to burst the pipe letting refrigerant go out or might ultimately burn the compressor motor itself.

It would, therefore. be in order to have OFF, FAN and COOL, three positions. The switches generally used by manufacturers are Line- 1, Line- 1 & II, Line- 1 & Line- OFF, which is translated into Fan, Cool, Fan, off. This is unsolicited on two scores. The cost of 4 - Position Switch is higher than the operation strictly warrants it and secondly it is confusing to the lay person, specially women, and children. Why should the user have to be specially instructed when better alternative method is available where no instruction on the score is necessary. Therefore, only 3 position switch as indicated above should be used.

The construction should be such as to withstand the surge of current on make and the arcing on break, it should be mechanically robust, the spring must not fatigue after several thousands of operation and the contact point not to be pitted or burnt after these operations.

In D. C. arc-quenching should be positively tested.