from the first should be liberally supplied with short branches and outlet valves, at least one to every 18 or 20 feet, with screwed ends to fit the union nuts of the flexible hose, the hose for hand tools and hoists varying from ⅜ inch to ½ inch diameter. Cords from the outlet valve lever run down to within 7 feet of the floor, controlling the position of the valve. Reservoir storage has to be proportionately the larger the more intermittent the work done—that is, the greater the extreme call for air compared with the maximum delivery of the compressor. The pipes and reservoir together should be capable of holding the total delivery of the compressor (working at normal speed), for half an hour, which is far cheaper than providing an excessively large size compressor, cheaper not only in first cost, but in daily working. This refers to steam power compressors, which are run to disadvantage at speeds so slow as to make uncertain if the fly-wheel is going to carry the crank well over its dead centre, and also the condensation on the cylinder walls, etc., is then excessive.

In ordinary compact factories, with fairly efficient steam plant, the gross cost of the motive power, that is, of fuel, oil and water, is but one per cent. of the total paid out in workmen's wages. In ironworking pneumatic power often increases a man's output of work 200 per cent. (threefold). For argument sake allow that it is only doubled. Then, if supplying one man with his proportion of the motive power were by the use of air to increase his proportion of the motive power cost by 50 per cent., it is evident we should then have a similar 50 per cent. margin for profit. As the actual cost is nearer 5 per cent., there is evidently a wide margin for extra outlay in machines or in their repair, which expenditure, per day or per man, is increased in the attempt to use pneumatic power, but in the cost of such tools as drills, rhymers, taps, boring cutters, etc., is not increased per foot run of actual work done, when compared with manual labor. Thus it is clear that if the additional machinery a factory makes or purchases in trying to use air as a distributor of power, is confined to such tools as will be often or fairly continuously used, this outlay is justified, and the cost of compressing relatively to total wages is so small that tools evidently wasteful in the use of air are economical, or rather show a net balance to the good, if the men find them portable, easily adjustable and handy to use, and their simplicity of make and freedom from repairs and breakdowns, results in but few delays to the steady output of work.

It is evident that the use of compressed air has stimulated the use of rotary-motors, and not because it was believed that they were economical converters, but because their light weight and small bulk permitted them to be used by hand. However, the making of a more perfect air engine than the steam rotaries, for which so many designs were made and patents taken out between 1830-50, has been attempted, but it is questionable if any advance has been made. The author has no information as to any attempt to use a reaction or impact turbine as a portable air motor. What has probably discouraged this is that the necessity to gear down the high speed would make the engine weighty and the friction excessive, although, as air at the same pressure is twice as heavy as steam, it looks as if air would do well in such a form of reaction engine. The most simple form of rotary motor is an eccentric or cam, forming part of the central shaft, whose length is that of the cylinder in which it rotates, and whose outer surface (belly) touches in the course of one revolution the whole internal circumference of the cylinder. A reciprocating plate moved in centrally from the cylinder wall receives the backward thrust of the air. The admission port is in front of this plate, and the exhaust port at its rear. So made, the small sizes to be held by hand, when at work, give an irregular, wobbling motion, as the shaft—or plug as it is called—is unbalanced. This long ago provoked the use of two parallel shafts or cams geared together, but the author must confess to a failure in an attempt to reverse a form of the Root blower, using it as a small motor. The later attempts make the cylinder in cross-section oval or elliptic, with several inlets and ports in its walls. The shaft, which is as large as the minor diameter of the ellipse, carries two or four movable blades or pistons in its body, whose outer edges are kept in contact with the varying walls of the cylinder, not by steel springs, but by the admission of compressed air to the bottom of the slots of the shaft in which each radial piston blade plays in and out. Without dispute, the leakage is large, judged by the standard of a reciprocating steam piston, in part due to the several reciprocating blades being subject to wear on their three outer edges, as well as looseness in their shaft slots, and also in part due to the fact that with air and steam under exactly similar conditions of surface, of metal, and of pressure, air will get past any packing more readily than steam will pass it. A suggested explanation for this is that the film of water that condensation leaves on the steam walls retards the passage of steam between smooth metal surfaces. The dynamic efficiency of such motors is low, so low as to apparently discourage any attempt at metering, indicating or brake-testing them, yet many wideawake shop managers use them in direct application to drills and taps, because, communicating a cutting speed from five to twenty times higher than can be given to the same tool by hand, they, therefore, prove cheap, although lavish in the use of air.

At the sacrifice of perfect portability much is gained by using small reciprocating engines, weighing from 100 to 200 lbs., with two to four cylinders receiving air pressure on one side only of the pistons.

Their light weight permits one man to readily move them over the shop floor; having no dead centre, gives prompt starting and regularity of turning movement; low centre of gravity gives steadiness; the strain being always in thrust, the engine is practically noiseless, and the elasticity of the air can be utilized in expansive working. The author uses double acting vertical engines (steam hammer type) of home manufacture, with single cylinder 3½ inches diameter by 6 inches stroke, averaging, with 80 lbs. pressure, 225 revolutions per minute. To re-warm the air just before it enters the valve-chest, it is passed through a 30-inch length of thin copper pipe, ⅜ inch outside diameter, bent into a four-turn truncated coil, barely 3½ inches diameter at base and 2¼ inches diameter at top, contained in a tin lamp 12 inches long by 3½ inches diameter at bottom and 1½ inches diameter at top. The lamp cistern carries a double "B" burner, using two ⅞-inch flat wicks, and burns an imperial pint of common coal oil each 30 hours. No glass chimney is required, and the flames come close to inside of coil. This lamp is bolted on close to and parallel with the cylinder, and is cheap, neat, and inconspicuous, working satisfactorily even when the engine is set at an angle of 15° or 20° out of vertical.