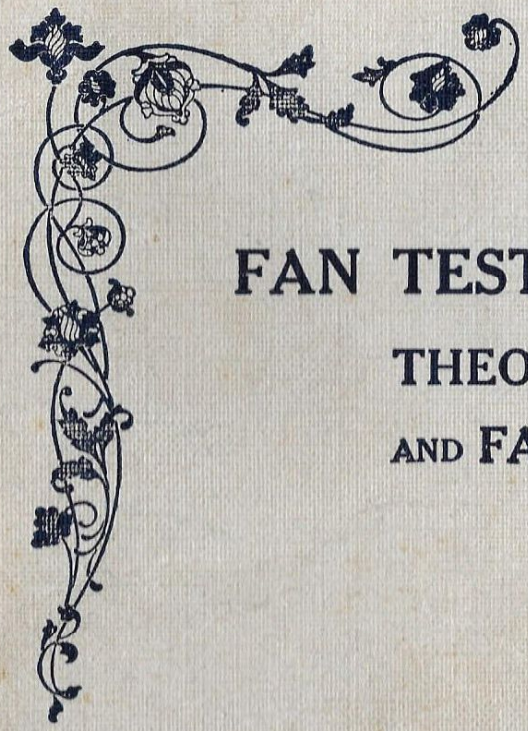
KEITH BLACKMAN





# FAN TESTS, THEORIES AND FACTS.

Article written for and forwarded to the *Engineering Review* of New York and Chicago, United States.

*1908*

# FAN TESTS,
## THEORIES AND FACTS.

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AS a Britisher, and, as one who passed his early manhood in the United States and Canada, and, who, by visits and otherwise, has kept in practically constant touch with his many American friends during his whole business career, I read with special interest everything American bearing on Fan design, construction, testing, practice, and theories; and in the November number of the *Engineering Review* appear two articles headed respectively "Tests on a 35-inch Exhaust Fan," by Professor Charles H. Chase, and "Fan Facts and Theories," by George H. Winstanley, F.G.S., both of which notices call for some attention.

The first Fan dealt with, being a purely American type, which has done good work in its day and generation, calls for more criticism than the other later and essentially British type referred to by Mr. Winstanley, which Fan has also made a name for itself second to none all over the world during the past decade.

It may be presumed that for the purpose in view, Professor Chase has selected the best known if not the best type of Fan generally that has emanated from the United States: consequently, it is right and fitting that the said Fan be placed in comparison with more modern Fans, so far as capacity and efficiency on test are concerned.

The Fan in question is called "*a 35-inch Exhaust Fan*," although the Fan Case in reality measures 37 inches from the top to the underside of feet or bracket supports : the fan wheel being of the Sturtevant type, and 24 inches in diameter, and having blades 8 inches in length at their tips or periphery edges.

The Fan—being an Exhaust Fan—has a single air-inlet with an eye opening measuring 14 inches in diameter, while the oblong outlet measures 12½ by 13½ inches : it is of course necessary that all these points be carefully noted.

Any comparisons made can only be based on the curves arranged by Professor Chase, and given in his Figure 13, which curves again consist of a series of tests taken with the Fan running at 1,200 revolutions per minute with four different sized outlets. These curves give at a glance the effective range of the said Fan.

Let us take (as closely as possible with the small scale on which they are put) the four points on these curves, and place alongside these, in the undernoted table, the results obtainable by actual test from the smaller but very latest Keith type of Fan doing identical work :—

| Cubic feet of air per minute. | Pressure in ounces per sq. inch. | The "35-inch Exhaust Fan" with 24 inch dia. Wheel. 14 in. Air-Inlet. | | The Keith Fan with Wheel 14 in. Diameter. 12½ in. Air-Inlet. | |
|---|---|---|---|---|---|
| | | Revolutions per minute. | Horse Power. | Horse Power. | Revolutions per minute. |
| 2,600 | 2·1 | 1,200 | 3· | 2·7 | 1,540 |
| 3,200 | 1·9 | 1,200 | 3·5 | 2·9 | 1,460 |
| 4,100 | 1·3 | 1,200 | 4· | 2·6 | 1,420 |
| 4,600 | 1· | 1,200 | 4·2 | 2·5 | 1,140 |



It may also be noted that in Professor Chase's Exhaust Fan there are five wide and deep squarish flat blades ; while in the Keith Fan there are 32 blades of conoidal form and parabolic curve : that the height of the Keith Fan Case is only 29 inches over all, as against the already given height of the said "35-*inch Exhaust Fan*" Case, *i.e.*, 37 inches ; and, further, that the outside diameter of the Keith Fan Wheel is only a little over one-third in area that of the "35-*inch Exhaust Fan*" Wheel.

The speed of the smaller, or Keith Fan Wheel, has been varied to get the volumes and water gauge for direct comparison : as this Fan gives a practically constant water gauge through this range with a constant speed : which is, of course, a great advantage over the so-called "35-*inch Exhaust Fan*" with which the pressure falls considerably under similar conditions. The average outside diameter of the Keith Fan Wheel is only 14 inches, against the 24-inch diameter of the other wheel.

It will be seen from the table that, taking the *total* of the whole range, to do the *same work* as the "35-*inch Exhaust Fan*," the much smaller Keith Fan requires nearly 30 per cent. *less total* horse-power than the said "35-inch Exhaust" Fan requires ; while (from the figures given on the last line of the table) the Keith Fan—handling 4,600 cubic feet of air per minute at 1 ounce pressure per square inch—only requires power to drive it, at the rate of 40 per cent. *less* than the power required by the "35-*inch Exhaust Fan*" to accomplish the same work ; in other words, the Keith Fan does the stated work with—from—30 per cent. to 40 per cent. *less* power than the other Fan.

It might therefore with justice be said in your correspondent's (Mr. Winstanley's) expressive language, that these figures "*knock on the head*" "many of the generally accepted theories with regard to centrifugal fans."

In order to give your readers some idea of the distinctive features of the "Keith" Fan, it may be said that it, is absolutely *novel ;* is the embodiment of all that is best in the scientific design and practical construction of fans ; and, is the result of years of almost continuous experiments. The Keith Fan, in fact (for volume-pressure work at

·58 up to 3·47 ounces per square inch—or, say, up to 6 inches water gauge), may be rightly claimed as the most up-to-date and efficient of Air-Movers; and may be used with equal efficiency for plenum *as* for extraction installations. The Fan may be had in the usual sizes in both single air-inlet and double air-inlet form. In the five smaller sizes, both the fan case and the wheel are formed of light sheet steel and are electric rivet-welded; although the fan cases, when desired, may be had of cast iron. In every size the wheel itself is exceptionally light and rigid in construction without requiring any kind of internal stays, and may be safely run at almost any practicable speed. The Fan is noiseless when working.

In the Single-Air-Inlet Keith Fan, the Wheel (as illustrated; Figs. 1 and 2—pages 8 and 9) takes the form of a double-conical truncated cone of different angles, composed of curved blades of conoidal formation having their deeper or inner ends set obliquely to the wheel axis; the diameter of the wheel both inside and outside being greatest where the blades are narrowest, and the longitudinal edges of the blades lying on conical surfaces differently inclined to the axis of the fan spindle.

In the Double Air-Inlet Keith Fan, the wheel (as illustrated; Figs. 3 and 4—pages 10 and 11) takes the form of two double-conical truncated cones of different angles, conjoined, having two air-inlets, and built up of two sets of blades of similar form to those in the single air-inlet wheel, connected to side rings and to central disc, both sets of blades having their concave surfaces set for running in the same direction, as shown; the diameters and proportions of wheel, and longitudinal edges of blades, being similar to those described for the single air-inlet wheel.

In both Single Air-Inlet and Double Air-Inlet Keith Fans, the wheel is enclosed in a volute case, *as* shown in the accompanying transverse and longitudinal sectional drawings on pages 12, 13, 14 and 15. The 32 conoidally formed and parabolically curved blades of the wheel in each case have an axial length of a little over 1½ times their average radial depth; the mean diameter in each case of the inlet-centre of the drum being fully twice the average radial depth of the blades:



the longitudinal edges of the blades being further apart at one end than at the other end, and of different angles; the blades are thus much shallower, towards the air-inlet or inlets, than they are at the back or base end in the case of the single air-inlet wheel, or, towards the centre, in the case of the double air-inlet wheel. Owing again to the outside diameter of the Keith Fan Wheel being greater at the air-inlet end or ends than at the disc, it follows that the blades are located further apart at the air-inlet end or ends than they are at their base, so that more air is drawn in or induced at the outer ends of the blades than at the inner ends.

Although the blades themselves are neither screwed nor twisted, their peculiar form and special or natural curve with different edge angles, and, their setting on the disc (bringing their deeper ends obliquely across the axis), give (in addition to the usual scooping, inducing and forcing action) a screwing action *on the air*—all tending towards increased efficiency. In all other forms of multiblade volume-pressure cased fans, the strongest air current is invariably at the base or back or disc ends of the blades, causing much *thrust*, and, having a tendency to cause recirculation of the air through between the blades at the inlet end or ends and thus back into the wheel centre or centres, which mean waste of energy and loss in efficiency.

Unlike all such forms of fan wheels having relatively long narrow blades, the Keith Fan Wheel, by reason of the varying proportions, different angles, and conoidal formation of the obliquely set blades—in conjunction with the increased induction towards the air-inlet or inlets caused by its double-truncated conical form, and its freedom from thrust—*ensures* the air delivery to be absolutely equalised along the whole length of its outer blade edges, and there is consequently an entire absence of any kind of air blow-off at any point of the air-inlet or inlets, as there invariably is at one point or other on the air-inlet edges of all other said forms of Fans.

With the phenomenal results and the enormous advance in air-movement and efficiency (as given in detail further on) it is not to be wondered at that the makers guarantee, by the Keith Fan, to give, with the same efficiency, 50 *per cent. more air* than can be

obtained from the best and most efficient volume-pressure fans of any other make already on the market, taking size for size of outer case, same size of outlet and inlet or inlets, at same water gauge, and running at same revolutions ; or, in comparison with such other fans and delivering same amount of air at same pressure, the Keith Fan is guaranteed to accomplish this with 20 per cent. *less* power at 15 per cent. *less* revolutions.

The following will show *some typical outputs* of the Keith Fans :—

Single Air-Inlet Keith Fan, with comparatively small inlet opening and fan case 29 inches high, delivers 1,200 cubic feet of air per minute against 2 ounces pressure per square inch, with wheel running at 1,200 revolutions per minute, and taking 0·9 horse-power. This example is given to show high *efficiency* at a fairly high air pressure (and not for volume), with a certain number of revolutions, and a limited or fixed horse power only available.

Single Air-Inlet Keith Fan, with 12½ inch diameter eye opening and fan case 29 inches high, delivers 3,200 cubic feet of air per minute at a pressure of 1·9 ounce per square inch, with wheel running at 1,460 revolutions per minute, and taking (as shown in the table) 2·9 horse-power.

Single Air-Inlet Keith Fan, with 17½ inch diameter eye or inlet opening and fan case 42 inches high, delivers 6,000 cubic feet of air per minute against one ounce pressure per square inch, with wheel running at 750 revolutions per minute, and taking 2·6 horse-power.

Double Air-Inlet Keith Fan, with 12½ inch diameter eye or inlet opening and fan case 29 inches high, delivers 7,000 cubic feet of air per minute at 1 ounce pressure, with wheel running at 1,100 revolutions per minute, and taking 3·4 horse-power. The Double Air-Inlet Keith Fans, being capable always of doing *double* the duty of the Single Air-Inlet Fans having the same wheel diameter, and requiring the proportionate increase of power.

It may be noted that the Keith Fan, in either Single Air-Inlet or Double Air-Inlet form, may be used for pressures up to 3·47 ounces



per square inch (or 6 inches water gauge), with the same high efficiency shown and claimed for the lower pressures.

Apart from the question of efficiency, the following examples will be sufficient to show the *capacity* of the Keith Fan in moving *volume* of air when the wheel is running in the Case with free intake and free discharge.

An electrically-driven Keith Fan, having *one* 12½ inch diameter air-inlet, and with a motor wound to run at 760 revolutions per minute, delivers 3,500 cubic feet of air per minute ; or, with a motor wound to run at 1,000 revolutions, the same Fan delivers or moves 4,600 cubic feet of air per minute.

The same size of Fan (so far as the diameter of the fan wheel and fan case and air-inlets are concerned), but with a wider case and *double* air-inlets and *double*-wheel to suit, with the same number of revolutions, delivers or moves in each case respectively 7,000 and 8,800 cubic feet of air per minute.

A Single Air-Inlet Keith Fan, having *one* 17½ inch diameter air opening, and running at 580 revolutions per minute, moves or delivers 7,300 cubic feet of air per minute ; while the same Fan running at 790 revolutions, moves or delivers no less than 10,000 cubic feet of air per minute.

The same size of fan, *i.e.*, having the same diameter fan wheel and fan case and air-inlets, but with wider case, *double* air-inlets and *double*-wheel to suit, with the same number of revolutions, moves or delivers in each case respectively 14,600 and 20,000 cubic feet of air per minute.

Fan Experts, Fan Makers, and Users, will fully appreciate the value of these figures and examples.

JAMES KEITH,

*Assoc.M.Inst.C.E. ; M.Inst.Mech.E.*

London, England, December, 1908.

ILLUSTRATION SHOWING SINGLE AIR-INLET FORM OF THE KEITH FAN WHEEL.

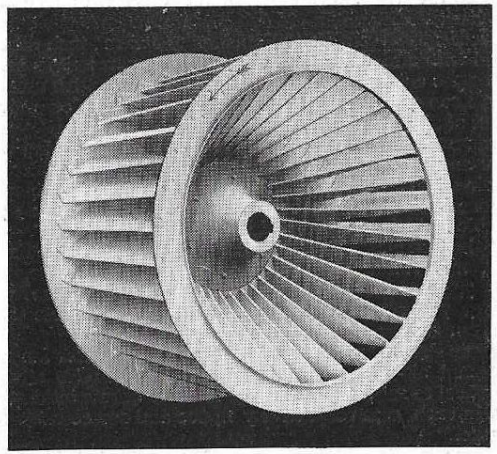

Fig. 1.

Single Keith Wheel, with shallower blades proportioned for handling air-volume at moderate pressures.



ILLUSTRATION SHOWING SINGLE AIR-INLET FORM OF THE KEITH FAN WHEEL.

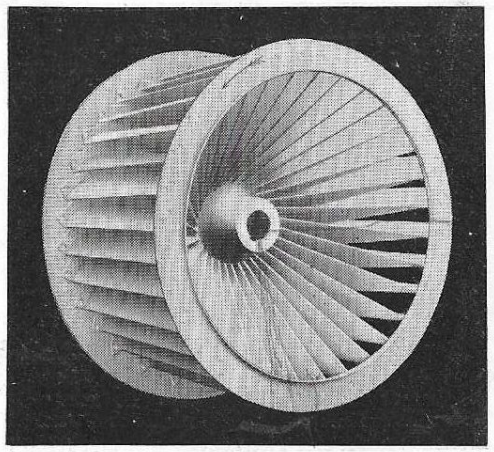

Fig. 2.

Single Keith Wheel, with deep blades proportioned for handling air-volume at higher pressures.

ILLUSTRATION SHOWING DOUBLE AIR-INLET FORM OF THE KEITH FAN WHEEL.

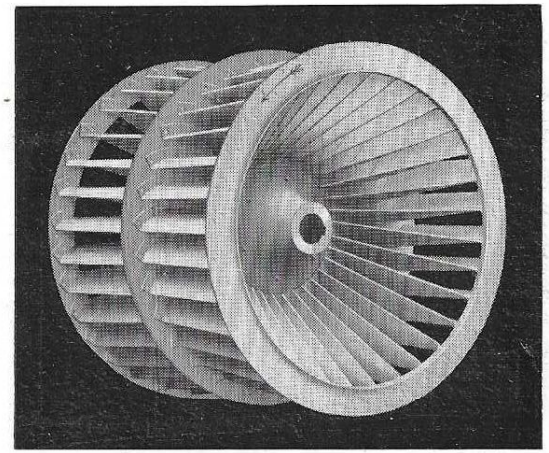

Fig. 3.

Double Keith Wheel, with shallower blades proportioned for handling air-volume at moderate pressures.



ILLUSTRATION SHOWING DOUBLE AIR-INLET FORM OF THE KEITH FAN WHEEL.

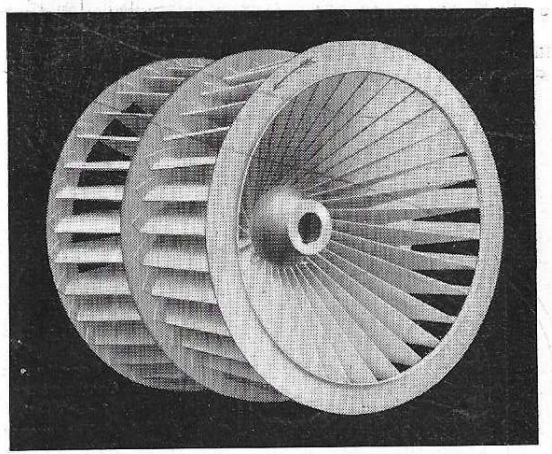

Fig. 4.

Double Keith Wheel, with deep blades proportioned for handling air-volume at higher pressures.

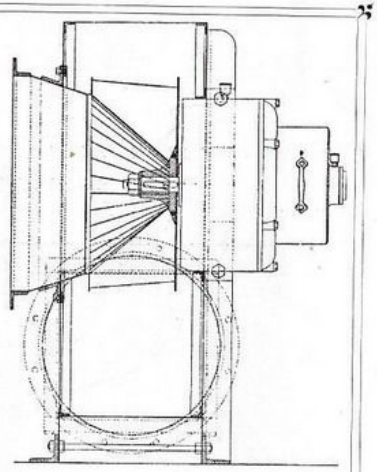

Fig. 5.

Transverse Section through Fan Case.
Longitudinal Section through Fan Wheel Blades.
Single Air-Inlet Keith Fan, direct Electrically-driven.

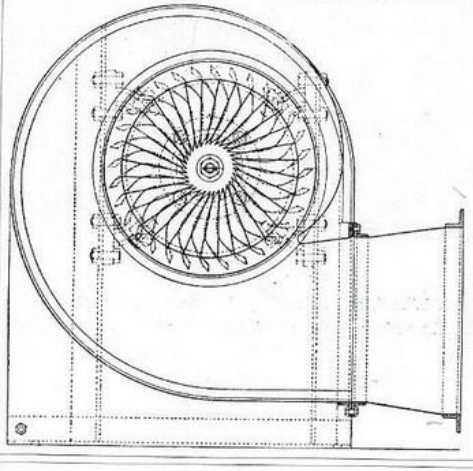

Fig. 6.

Longitudinal Section through Fan Case.
Transverse Section through Fan Wheel.
Single or Double Air-Inlet Keith Fan, direct Electrically-driven.



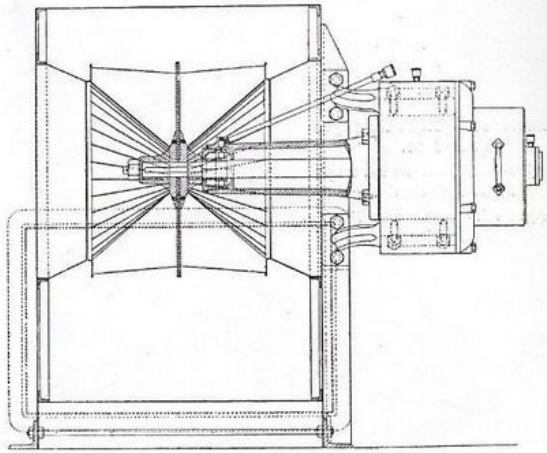

Fig. 7.

Transverse Section through Fan Case.
Longitudinal Section through Fan Wheel Blades.
Double Air-Inlet Keith Fan, direct Electrically-driven.

KEITH FAN—ELECTRICALLY-DRIVEN—WITH DEEP BLADES PROPORTIONED TO HANDLE AIR-VOLUME AT THE HIGHER PRESSURES.

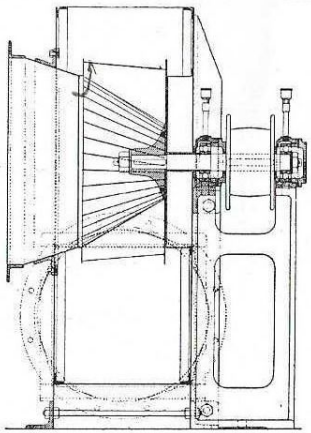

Fig. 8.

Transverse Section through Fan Case.
Longitudinal Section through Fan Wheel Blades.
Single Air-Inlet Keith Fan, Belt-driven.

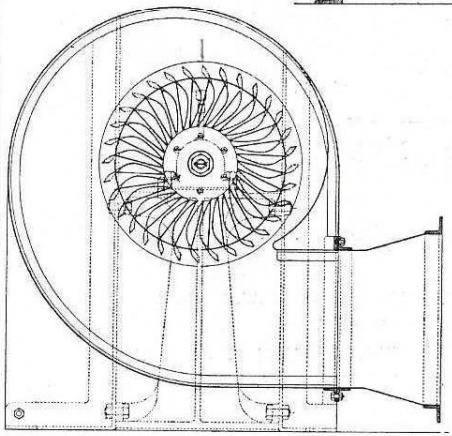

Fig. 9.

Longitudinal Section through Fan Case.
Transverse Section through Fan Wheel.
Single or Double Air-Inlet Keith Fan, Belt-driven.



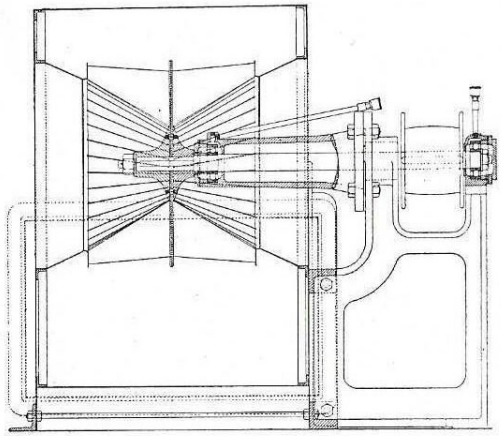

Fig. 10.

Transverse Section through Fan Case.
Longitudinal Section through Fan Wheel Blades.
Double Air-Inlet Fan, Belt-driven.

KEITH FAN—BELT-DRIVEN—WITH SHALLOWER BLADES PROPORTIONED TO HANDLE AIR-VOLUME AT MODERATE PRESSURES.