Abbreviated Sectional Catalogue.

VENTILATING MACHINERY.

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Walker Brothers,

ENGINEERS,

Pagefield Ironworks,

WIGAN, ENGLAND.

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WALKER BROTHERS,

Engineers and Iron Founders,

PAGEFIELD IRONWORKS, WIGAN, ENGLAND,

MANUFACTURERS OF

WALKERS' PATENT AIR COMPRESSING ENGINES

AND

BESSEMER BLOWING ENGINES.

WALKERS' PATENT VENTILATING FANS.

HORIZONTAL AND VERTICAL STATIONARY AND LOCOMOTIVE ENGINES.

SECTIONAL CATALOGUE—VENTILATING MACHINERY.

CONTENTS.

INTRODUCTION TO THE GENERAL CATALOGUE.

IN the following pages we have endeavoured to give the reader a brief description (assisted by illustrations) of the principal kinds of Machinery we construct.

As it would be impossible, within the limits of an ordinary Catalogue, to describe in detail everything we manufacture, we shall have pleasure in supplying full specifications of our Machinery to intending purchasers on receipt of enquiry.

We respectfully beg to state that the illustrations and descriptions of the Machinery contained herein are to be taken as approximate only, and we reserve to ourselves the option of altering the same without notice, or withdrawal of this Catalogue, as we may from time to time consider to be advantageous.

THE PAGEFIELD IRONWORKS.

The Pagefield Ironworks, Wigan, are situated in the centre of the South Lancashire Coal and Iron districts.

The Lancashire and Yorkshire Railway adjoins the Works on the North side, and is connected with them by means of sidings; the Leeds and Liverpool Canal forms the boundary on the South side, so that direct railway and water communication are afforded for the delivery of raw materials, and the despatch of finished machinery and ironwork.

The site of the Works occupies an area of about ~~seven~~ eight acres. The chief productions are machinery required at Collieries, Metalliferous Mines, Chemical and Ironworks, but machinery is also manufactured for many other purposes.

WORKSHOPS.

The Works comprise the Machine Tool and Erecting Shops, Smiths' Shop, Pattern Shop and Foundry. Adjoining the Engine Works is the Forge—the property of the Pagefield Forge Company—but under our general direction.

WALKER BROTHERS.

JOHN SCARISBRICK WALKER, M. Inst. C.E.
THOMAS ASCROFT WALKER.
EDWIN ROBERT WALKER.

PREFACE TO THE GENERAL CATALOGUE.

WE beg to state that our experience as Mechanical and Mining Engineers commenced forty years ago; two members of our firm being Mechanical Engineers, one a Mining Engineer. As the chief part of our business is to construct machinery for mining purposes, the advantages are considerable in possessing practical experience of the circumstances, and in the working of Collieries and Mines. We do not confine ourselves, however, to the supply of mining machinery, as we have had a large experience in the construction of machinery for Steel Works, Chemical, and other Works.

For many years we have been in daily communication with the Managers and Engineers of the most important Collieries in the country, and with many Mines abroad. We have thus been able to acquire an accurate knowledge of their requirements, and to adapt our machinery, when in process of design or construction, to the needs of mining growth and enterprise Our special experience has enabled us to grapple successfully with new problems in the mechanical engineering of Collieries and Mines, as they have from time to time presented themselves. An example of this may be quoted, as at the period when the ventilation of Collieries by furnaces was declared to be wasteful, and a more economical means was desired.

In 1872 we commenced the manufacture of Ventilating Machinery, working under the patents of M. Guibal. We constructed in succeeding years a large number of Guibal Fans with their steam engines, many being the most powerful, perhaps, in this country. For moderate volumes of air and low water gauges, these Fans work well, but for the heavier duties now required, we designed machinery more suitable for the altered circumstances, which is referred to more particularly elsewhere in this book. We have constructed Ventilating Machinery with an exhausting power in the aggregate of 40,000,000 cubic feet of air per minute. Our experience in ventilation has not been confined to Collieries, as we have supplied machinery to ventilate the longest and most important railway tunnels in the country. In this department of our business (Railway Tunnel Ventilation) we have been honoured by the confidence of the most eminent Civil Engineers, viz.:—the late Sir John Hawkshaw; Sir J. Wolfe-Barry, President Inst. C. E.; the late Mr. Harrison-Hayter, President Inst. C. E.; the late Sir James Brunlees, President Inst. C. E.; Sir Charles Douglas Fox, Vice-President Inst. C. E.; Mr. F. Fox, M. Inst. C. E., and others. These gentlemen have expressed their complete satisfaction with the work we have executed for them. Our large and varied experience in ventilation enables us to advise on all questions of this department of engineering.

AIR COMPRESSING ENGINES, and the machinery driven thereby, have received an equal degree of our attention during the last thirty years. We refer more in detail to this class of machinery elsewhere, but we beg to state that our experience is represented by machinery of an aggregate total of 230,000 Indicated Horse Power, and as contained in about 550 large installations as constructed by us for a variety of purposes. These engines are at work in England and Wales at Collieries, Chemical Works, Bessemer Works—and abroad at Gold Mines, Silver Mines, &c., &c.

UNDERGROUND HAULAGE OF MINERALS.—This branch of Colliery Engineering has received our attention for many years. The circumstances underground are so varied, that each installation requires special knowledge and experience in its design and arrangement. The importance of the matter generally has been recognized by the numerous Papers on Underground Haulage, read at the meetings of Mining Institutions. It is essentially a subject for the Mining and Mechanical Engineer. We possess this combination of experience. We have supplied our patented machinery for the Endless Rope system of Haulage under the most difficult circumstances existing in this country. We have arranged and applied the Endless Rope system successfully at Collieries where it was previously considered an impossibility. Many examples of the machinery for this purpose are exhibited in this book. Section

WINDING OR HOISTING ENGINES FOR COLLIERIES AND MINES.—This catalogue contains photo-prints showing a variety of forms of this description of machinery. Some are representative of the most powerful installations existing in the country.

LOCOMOTIVE ENGINES.—We provide in this book photo-prints representing the various kinds of Locomotives we supply for Collieries, General Works, and Contractors' purposes. We refer the reader to the special section of our catalogue for a more full and detailed description of the same.

We also exhibit prints taken from photographs of many other kinds of machinery.

In all cases, we construct high class machinery only. Experience has proved the foolishness of supplying machinery of a lower grade character. In designing machinery the Engineer profits by experience. It is no disparagement to his knowledge and ability if later efforts improve on that which he has before executed. It is in the nature of engineering work that experience should show the possibility of improvement on previous work. The locomotive and the lathe of to-day are very different machines from those existing in Stephenson's life-time. The improvements have been effected by departing from previously existing designs, which doubtless would be considered excellent at the time of their preparation.

It must therefore be understood that if the machinery we supply to-day is superior to that we formerly constructed, the improvement is due to the legitimate progress of engineering experience. A stereotyped stand still policy has not been ours hitherto, and will not be so in the future. The illustrations in this book must be regarded therefore in the light of the knowledge of these facts. A few of the prints may represent machinery which is now almost obsolete in comparison with our more recent practice, and that which exists to-day, in its turn, may be left behind a few years hence by something better.

General Conditions on which we tender for the supply of Machinery, and on which orders can only be accepted by us.—WALKER BROTHERS.

GENERAL CONDITIONS OF TENDER FOR MACHINERY FOR HOME USE.

If any time be fixed for the delivery of the Machinery or its completion, such time shall be extended in cases of strike, lock-out, or stoppage of workmen, defective castings or forgings, etc., break-down of machinery, fire, or other unforeseen causes of delay.

In the case of Machinery erected in Great Britain or Ireland, any portion thereof which can be shown to have failed in any reasonable time through any defect in material, or workmanship, will be replaced, but no responsibility will be undertaken, or claim entertained for any consequential or other damages arising from such failure.

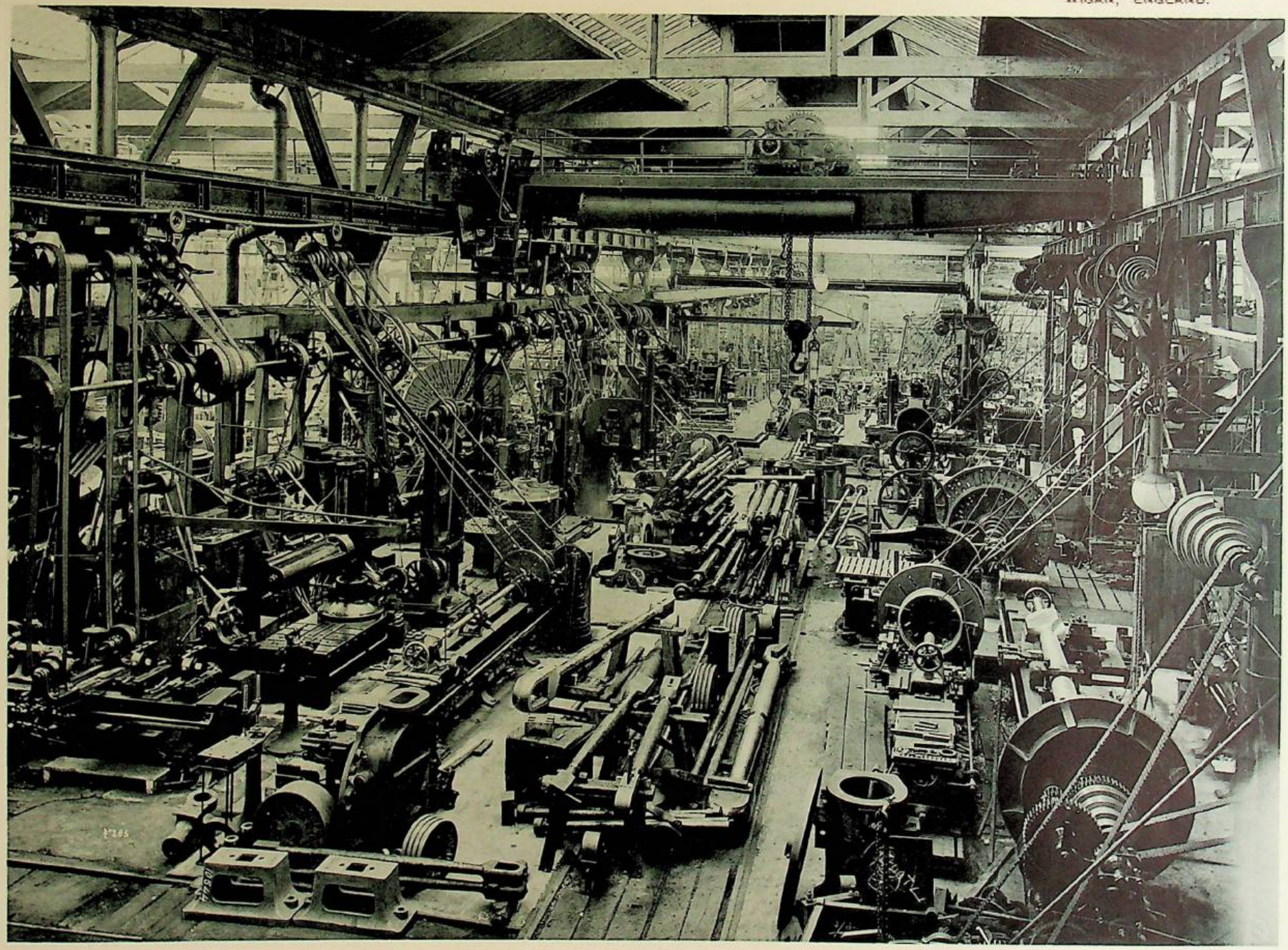
Illustrations of our Machinery are to be taken as showing the general design only, and not as binding in detail, in any way.

GENERAL CONDITIONS OF TENDER FOR MACHINERY FOR SHIPMENT.

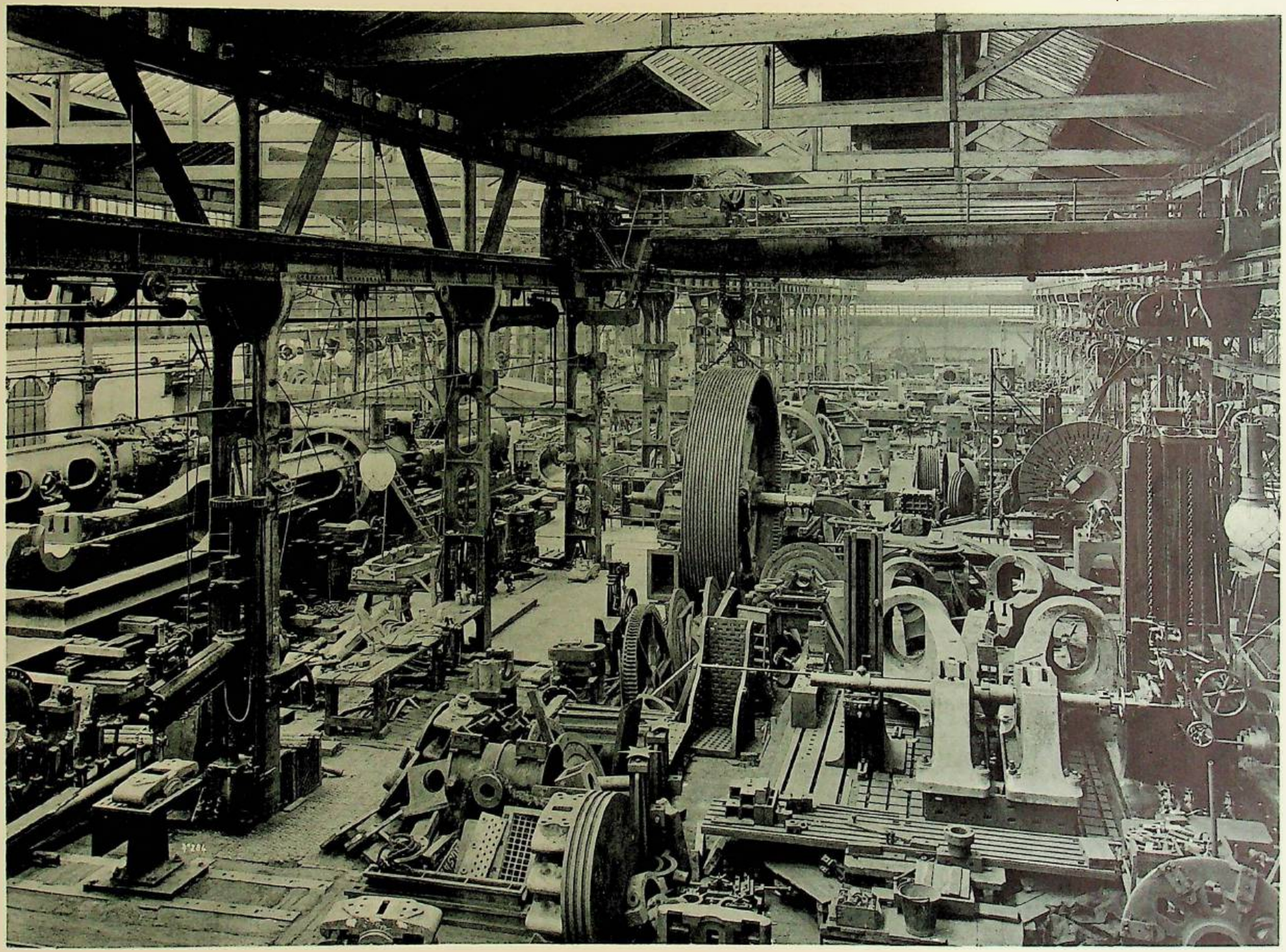
If any time be fixed for the completion of the contract, such time shall be extended in cases of strike, lock-out, stoppage of workmen, defective castings or forgings, etc., break-down of machinery, fire, or other unforeseen causes of delay.

Every facility will be given to purchasers for the inspection and examination of Machinery intended for shipment, and its packing at our works, and purchasers are invited to make such inspection, as no responsibility will be undertaken, or claim of any description entertained after the Machinery is shipped.

Illustrations of our Machinery are to be taken as showing the general design only, and not as binding in detail, in any way.



PAGEFIELD IRONWORKS.—No. 285. Interior view of one of the bays of the Erecting Shops, Pagefield Ironworks. There are five similar bays forming the Machine Tool and Erecting Shops. The larger overhead Cranes in these Works (Engine Works and Foundry) are driven by Compressed Air.



PAGEFIELD IRONWORKS.—No. 284. Interior view of one of the bays of the Erecting Shops, Pagefield Ironworks. There are five similar bays forming the Machine Tool and Erecting Shops. The larger overhead Cranes in these Works (Engine Works and Foundry) are driven by Compressed Air.

WALKER BROTHERS,
ENGINEERS.

PAGEFIELD IRONWORKS,
WIGAN, ENGLAND.

PAGEFIELD IRONWORKS.—Photo-print No. 292 shows the Interior of the Foundry at Pagefield Ironworks. The large overhead Cranes in these Works (Engine Works and Foundry) are driven by Compressed Air.

COLLIERY, MINE AND RAILWAY TUNNEL VENTILATING MACHINERY.

(WALKERS' PATENTS.)

We have had 26 years' experience in the construction of Ventilating Machinery for Collieries and Railway Tunnels. We have a large number of Fans in operation for the heaviest duties required in this country, viz :—a ventilating power from 250,000 cubic feet of air per minute, with water guages of 4 inches to 6 inches, to 500,000 cubic feet per minute with 6 inches water gauge. We are prepared to provide installations for still higher duties than the latter if required. In some cases we have supplied Fans for considerable volumes of air with 10 inches of water gauge. In addition to the above we supply Fans for all duties commencing at 20,000 cubic feet of air per minute, with a water gauge of one inch. As to the mode of driving Fans, we supply them directly driven by the engine, or from the engines by ropes or leather belts, as may be preferred. (We refer to this elsewhere.)

The leading features in the constructive design and mode of working of our Ventilating Machinery are strength, high utilized effect of the power, moderate velocities, and easy access to all details for inspection.

We have had considerable experience in the working of very large Fans (up to 46 feet diameter) moving at slow velocities and of small Fans working at high velocities. This experience has resulted in recommending to our friends a mean between the two. This is afforded by our rope driven Fans. The advantages of moderate velocities are retained by the suitable proportioning of the speeds of the Engines and the Fan, more especially as to relative number of revolutions of the crank shaft and the Fan shaft. We deprecate high velocities for these details.

Where the steam pressure is suitable, we most frequently supply engines on the Compound Condensing principle for ventilating purposes.

We construct engines for Fan driving with valves of the Corliss type, as well as with slide valves, the latter are almost invariably provided with Meyer's Expansion Gear, regulated by hand. Briefly, it has been our chief object to supply Ventilating Machinery which will bear continuous working without stoppage for repairs, and with the least expenditure for fuel and general cost of maintenance.

To the present date the aggregate exhausting power of the Ventilating Machinery we have constructed for Collieries, etc., amount to 40,000,000 cubic feet of air per minute.

We have received from Mining Engineers a large number of unsolicited testimonials, giving particulars of the duties obtained by our Fans at collieries under their management, which prove that our machinery gives a useful effect surpassed by no other existing installations of Colliery Ventilating Machinery. We supplied the machinery to ventilate the Severn Tunnel, the Mersey Tunnel, the Glasgow Central Railway (Argyle Street Section), the Midland Railway Tunnel (King's Cross and Camden Road) and other Railway Tunnels. While we strongly recommend our newest form of Fan, which we have styled the "Indestructible," as being the most efficient in ventilating power, and of the most durable form as to construction, yet we continue to supply the Guibal Fan when required. We constructed a large number of Guibal Fans in our earlier experience—many up to 46 feet diameter—which continue to work satisfactorily. We recommend them now, however, for moderate duties only, and for low water gauges. All the advantages of the Guibal are equally contained in our "Indestructible" Fan, but the former does not possess the special merits of the latter. When required, we supply Fans on the "Schiele" principle, with which we have embodied several improvements on their original designs. We apply our patent "Anti-vibration Shutter" to this Fan, which effectually diminishes vibration, and prevents noise during working.

For the purpose of colliery ventilation, it is almost impossible to give too much care and attention to the general design and to the workmanship of the Steam Engines which are to drive the Fan, so as to ensure safety in working, and the minimum amount of risk to break down. We have endeavoured to supply Colliery Proprietors with Ventilating Machinery as a whole (Engines and Fan) to produce a high useful effect, and to be of sufficient strength to prevent breakdowns and stoppages.

It has been stated by leading Mining Authorities that an ideal useful effect should not be purchased at the cost of a dangerous limit in the strength of the machinery. It must be remembered that the greater number of colliery Fans work almost continuously for 365 days and nights to the year, and with scarcely any time of stoppage for examination or repair. Recognising the liability to breakage in all machinery, leading Mining Engineers have declared it to be necessary and desirable

that the more important machinery at Collieries should exist in duplicate, and this wisely expressed opinion applies most forcibly to Ventilators, both engines and Fans. Many Colliery Companies have already erected the Ventilating Machinery in complete duplicate.

The true measure of the economical merits of a complete Ventilating Machine, Fan and Engines, is the cost of fuel and maintenance of the machinery, taken over a lengthened period of actual working, together with the power of ventilation afforded to the mine. This we state in contra-distinction to a merely local useful effect, which is frequently put forth as an infallible indication of the efficiency of the Fan. We have given equal attention to the two halves of the complete Colliery Ventilator, *i.e.*, Fan and Engines, and we shall continue to do so. We attach importance to the properly proportioned relative velocities of the Fan and the Engine which approximately may be regarded as about two or three of the Fan on its shaft to one of the crank shaft of the engine. We now refer to Fans when rope or belt driven.

We wish to add a few words on the question of comparative useful effects produced by various types of Fans. It appears to us that the only means of obtaining accurate comparative tests of complete Ventilating Machines, would be to place the competitive installations at the same colliery, and to have the tests of each competing Ventilator made under precisely similar conditions, including that of the atmosphere; that tests for each Fan should be extended over a considerable period; that daily or more frequent measurements be taken of the air volume exhausted and the vacuum produced as shown by the water gauge; that accurate measurements of the coal consumption and of the lubricating material be also taken, and that these tests be supervised by thoroughly impartial men. But, even then the test would not be a complete one, as the cost of wear and tear, and also the cost of maintenance, could not be obtained unless this test were continued over a period of years.

In some cases Ventilating Machinery of a comparatively temporary and inexpensive character may suffice, in others first cost is secondary, because of the probable extended life of the colliery. In both cases, however, breakdowns are costly.

We have endeavoured to produce a Colliery Ventilating Machine of the highest efficiency and economy, as shown by the least annual expenditure on fuel, on lubricants, and general wear and tear. The Ventilating Machinery as represented in this book we wish to be judged from this stand-point only.

The duties attainable from the Fans we have already constructed, range from 20,000 to 500,000 cubic feet of air per minute, and some with water gauges as high as 10 inches. As we before stated, we are prepared to supply machinery for much greater duties than these, if circumstances require us to do so. There is a substantial reserve of ventilating power in

the majority of the Fans we have constructed for colliery purposes beyond the originally prescribed duty, and this we consider it desirable they should possess, and should be allowed for in construction.

Messrs. J. & R. STONE, PARK COLLIERIES, Near WIGAN.—Mr. Higson, the former Manager of Messrs. Stones' Collieries, in a paper read before the Manchester Geological Society, gave the following particulars as the results of carefully made tests of the working of our Fan ventilating these mines:—

Revolutions of Engine.	Revolutions of Fan.	Air Volume.	Water Gauge at Pit Top.	Useful Effect.
40	84·6	201,096	3 inches	61·70 per cent.
46	98·5	232,073	4 „	63·71 „
51·3	110	262,925	5 „	64·30 „
56	118	286,895	6 „	67·54 „

WHERE TO TAKE THE WATER GAUGE.—We consider that the proper place to take the water guage is at the pit top, and not at the Fan inlet, as the former position more accurately shows the exhausting influence which the Fan has upon the mine; but as some makers of Fans base their "Useful Effect" upon the water gauges taken at the Fan inlet, for the sake of comparison we give a second table of Mr. Higson's tests:—

Revolutions of Engine.	Revolutions of Fan.	Air Volume.	Water Gauge at Fan Inlet.	Useful Effect.
40	84·6	201,096	3·6 inches	73·73 per cent.
46	98·5	232,073	4·7 „	74·00 „
51·3	110	262,925	5·7 „	73·72 „
56	118	286,895	7·1 „	79·67 „

COST OF LUBRICATION.—Mr. Higson's experiments proved that the average cost of six week's lubrication of the Fan shaft bearings was 7½*d.* per week.

FUEL CONSUMPTION.—Mr. Higson also stated that in a carefully conducted test, the fuel consumption was 2·6 lbs. of slack (small coal) per horse power per hour in the engines.

INSTANCE OF COST OF LUBRICATION INCLUDING ALL NECESSARY STORES.—We have recently received a report from a Colliery Company in the Midlands, for whom we erected one of our Fans about two years ago, in which they state that the cost of the stores necessary for the working of the Fan, including oil, packing, cleaning waste, etc., is not more than 2*s.* 6*d.* per week, this cost being taken upon an average of many weeks working.

USEFUL EFFECT from 60 to 78 per cent.—We have been supplied by the Managers of collieries from time to time with particulars as to the working of our Fans, which show that the useful effect obtained, based upon the water gauge taken away from the Fan inlet, and away from the local influence of the Fan, is from 60 to 78 per cent. We claim that no Fan of equal dimensions, and running at equal velocities, shall produce a higher useful effect and exhaust a greater volume of air than our own. We name this lest it should be erroneously supposed that, while we may sometimes recommend a larger Fan than some of our competitors for a given duty, our Fan is inferior in exhausting power.

THE ADVANTAGE OF MODERATE VELOCITIES.—The most economical results are obtained by a moderate number of revolutions of the Fan, and the special construction of the "Walker-Indestructible" enables us to offer Fans of such a diameter as to give this without unduly increasing the weight upon the bearings, whilst at the same time, affording a greater margin of reserve and exhausting power for emergencies which may arise. A serious objection to "high speeds" is the more frequent adjustment of the working parts, and the limited time available in Colliery Ventilating Machinery for such adjustments.

COMPARISON BETWEEN DIRECT-DRIVEN AND ROPE OR BELT DRIVEN FANS.—Although our Fans are equally suitable for being "directly driven" as any other Fan (and we have had a very large experience in this mode of working them), yet we are of opinion that "driving" them by belts or ropes, and more especially for the higher duties, is the better plan. The belt or rope affords an elastic medium between the somewhat impulsive action of the steam engine and the uniform motion of the Fan, and any tendency to "knock" is diminished. As a consequence the engine and Fan work more smoothly when thus separated, and a higher duty can be obtained. A further advantage is that greater scope is afforded of modifying the relative velocities of the engine and Fan, if found necessary by the varying circumstances of the mine, as by changing the pulley on the Fan shaft from one diameter to another (a simple matter), the speed of the Fan may be increased or decreased, while retaining a uniform velocity of the engine. This easy method of changing the velocity of the Fan, while retaining the same velocity of the engines, is especially desirable where the workings

of a colliery are being "opened out," and where, at the outset, it has been found impossible to do otherwise than assume what the water gauge for any given air volume may be.

THE CONTINUOUS WORKING OF VENTILATING MACHINERY.—This class of machinery is subjected to more incessant and continuous working than marine engines, mill engines, or perhaps any other machinery, and with fewer opportunities afforded for repairs or adjustment, as a consequence every detail should be most carefully prepared.

A FAN CONSTRUCTED FOR A 10 in. WATER GAUGE.—At a Midland Colliery it was necessary to erect the Ventilating Machinery in the mine (about 200 yards from the pit bottom) to ventilate one particular district, about three miles in-bye. The water gauge required was exceptional, viz., 10 in. The Fan has now been at work some years, a 7 in. water gauge supplying the necessary ventilation for the present requirements. The Fan has been tested to its fullest capacity, and the Proprietors of the Colliery have on several occasions expressed their entire satisfaction with the machinery.

We have received the only Gold Medal awarded in the mining section of the Newcastle-on-Tyne Exhibition for our improvements in Colliery Fans. This Exhibition was essentially a Mining Exhibition, and the Jurors were Mining Engineers and Colliery Proprietors.

RAILWAY TUNNEL VENTILATION.

In addition to our greater experience in the Ventilation of Collieries, as already stated, we have had a considerable experience in the Ventilation of Railway Tunnels, including the Mersey Railway, the Severn Tunnel, the Glasgow Central Railway, Midland Railway Tunnel (between King's Cross and Camden Road), and others. Extracts given below from the "Report of the Committee appointed by the Board of Trade to enquire into the system of ventilation of tunnels on the Metropolitan Railway," will show that the ventilation of the railway tunnels named above was done to the satisfaction of the Engineers of the respective Railways. With reference to the Mersey Tunnel, Mr. Francis Fox, M. Inst. C.E., stated in reply to the questions put by the Committee, that the construction and the working of the various installations we supplied for the ventilation of this Railway were perfectly satisfactory. The machinery comprises five powerful Fans with their Engines, four being of the Guibal construction, and one, erected more recently, of our "Indestructible" type.

REPORT OF COMMITTEE OF BOARD OF TRADE.

Committee:—Major F. A. Marindin, R.E., C.M.G., Chairman, Earl Russell, Sir Douglas Galton, K.C.B., Sir Charles Scotter, and Dr. John Scott Haldane.

[A diagram was referred to by Mr. Fox.]

In reply to a question from Sir Douglas Galton (No. 727), as to the means of preventing noise and vibration, Mr. Fox said:—"In order to avoid that, Messrs. Walker of Wigan, who constructed all our Fans, hit upon a very ingenious device for overcoming pulsation. This Fan, revolving like a paddle wheel in a chamber, is provided with what they call a shutter, and that shutter has generally a horizontal edge to it. The consequence is that as each vane passes that shutter a pulsation, or a pulsatory action is produced, and the number of pulsations that are produced, is that when they are running say at 60 revolutions a minute, amounts to 864,000 blows during the 24 hours. The consequence is often destruction of the Fan and the production of a very objectionable noise, therefore Messrs. Walker hit upon this very ingenious idea, that, instead of having a horizontal edge to the shutter, they have cut out a great vandyke as you see there (diagram referred to); and the air, instead of being abruptly cut off, is tapered off, and, as each moment the width of that is growing less and less, the result is that the Fans are silent. You can put your ear against the building in which the Fans are running, and there is no pulsatory effect produced at all."

Question 728.—"What is the pulsatory noise occasioned by?" Reply.—"The air in the Fan is under a slight water-gauge; there is a partial vacuum. Owing to the air coming in and being whizzed round by centrifugal force, there is a certain water-gauge. In the chimney there is no water-gauge, the consequence is that the moment the air gets relief there is a slight condition of pressure here (diagram referred to), but there is none there, and there is a blow produced as each vane passes the edge of the shutter; but, by making it a better shape, that is obviated entirely."

Question 731.—"Is there a Fan on the Midland Railway, somewhere in London?" "Yes, there is a Fan working on the line between the King's Cross Station and St. Paul's Road. The result, I may say, having visited all the Fans, is that it is the only Fan worth speaking of in London producing satisfactory results. It is 14 feet in diameter, and it is throwing about 132,000 feet of air per minute."

Question 732.—"Is it a Guibal Fan?" "Yes, it is. It is made by the same people, Messrs. Walker Bros. It is a high speed Fan, and it takes the air in at both sides of the Fan. That is a very important point on which I may, perhaps, say just one word to you. A Fan ought to have

fresh air coming in on the two sides of the paddle wheel, because if you only have it on one side you get a side thrust, and you also do not get anything like the same yield of air that you do where you get it on both sides. The Midland Fan takes it on both sides, and it is doing very good service."

Question 733.—"Do you know the length of the tunnel it is ventilating?" "It is 1,396 yards." [The Fan referred to is not a Guibal, but an "Indestructible."—Walker Bros.]

VENTILATION OF THE SEVERN TUNNEL.

(Great Western Railway Company.) Length about 4½ miles.

In reply to questions from the Members of the Committee, Mr. Harrison-Hayter, past President of the Institution of Civil Engineers, stated as follows :—

Question 1058.—"I think you have specially studied the question of the ventilation of tunnels?" Reply.—"Yes."

Question 1059.—"On more than one occasion?" Reply.—"On several occasions for the past 30 years I may say; I have studied it in connection with the Channel Tunnel, in conjunction with my late partner, Sir John Hawkshaw, who was the promoter of the Channel Tunnel, and also in connection with the Parks Railway."

Question 1060.—"You have carried out some ventilation works yourself, have you not?" Reply.—"Yes. We were Engineers to the Severn Tunnel, which is ventilated by a Fan."

To Question 1061, Mr. Hayter replied :—"I may, perhaps, say at the outset, that the ventilation is quite perfect, and that the engine drivers say they wish all Railways were like it, because they are under shelter, and they have air as pure as the air outside. This Tunnel is ventilated by one Fan; that Fan is 40 feet in diameter, and it is 12 feet wide, and is capable of being worked up to 45 or even 50 revolutions per minute."

Question 1063. In reply to the Chairman, Major F. A. Marindin, R.E., C.M.G., Mr. Hayter stated that: "With the Fan working at a velocity of 43 revolutions per minute, the volume of air abstracted from the tunnel would be 450,000 cubic feet per minute."

Question 1068. Reply.—"At 26 revolutions per minute, at which rate the Fan is worked now, the combined velocity is about 7 miles per hour, and that is split up in this way. The velocity through the Welsh end is 4 miles per hour, and through the English end 3 miles per hour. The velocity of air abstracted at those velocities is 275,000 cubic feet per minute." In reply to further questions, Mr. Hayter described the Fan and its Engines.

Mr. J. C. Inglis, Chief Engineer of the Great Western Railway Co., and Member of the Council of the Institute of Civil Engineers, stated in his evidence to the Committee (Question 3099) :—"That he was thoroughly satisfied with the ventilation of the Severn Tunnel."

Sir John Wolfe Barry, President of the Institute of Civil Engineers, and Consulting Engineer for the Metropolitan Railway, in his evidence before the Committee on the general question of Railway Tunnel Ventilation, mechanically effected, or by blow holes into the streets, stated with reference to ourselves as follows :—

Question 589. Reply.—"We took the advice of the best man on the construction of Fans that we could find,—the man who makes many of the great Fans for Collieries,—Walker of Wigan. He designed the Fans. We told him what was wanted, and he did the very best he could, and I could not find any fault with them."

Sir John Wolfe Barry instructed us to supply the Ventilating Machinery for the Glasgow Central Railway (Caledonian Railway Co.), which we have completed to his perfect satisfaction, and to that of the Railway Company. This machinery has now been working for nearly two years.

COLLIERY VENTILATING MACHINERY.

The following Notes refer to the Photographic Prints in our Complete Catalogue.

The photographic prints in the Colliery Ventilating Section of our Catalogue represent a few out of a large number of installations of this description of machinery. The majority of the steam engines are on the coupled-compound, or twin-compound principle, having condensing apparatus worked by a trail crank from the main crank shaft. We sometimes supply a tandem-compound condensing engine, as shown by print No. 184, to which can be attached a duplicate stand-by engine fixed in the same line. The stand-by engine can be made tandem-compound, or simple-high-pressure, as desired. There are certain advantages in the twin-compound engines over the tandem-compound, but both work well. As a rule we recommend the former, as engines when paired, or coupled, work more smoothly,—the cranks being fixed at right angles on the crank shaft, and the power more evenly distributed.

We recommend expansion, or variable cut-off valves, to be applied to both the high-pressure and the low-pressure steam cylinders for fan driving engines.

Although the fan engines shown in this book have Slide valves, yet we can supply engines with Corliss valves on the steam cylinders, if desired.

We have a variety of forms in the general arrangement, and in the details of our engines for fan driving, to suit the requirements of our colliery friends.

A few of these only are exhibited in the pages of this book. The Photo-print No. 232 will be observed to differ in form from the majority of the other prints, more especially as the cylinders are attached to the ends of the foundation plates, in the style used for the Corliss type of engine.

This photograph (232) does not fully represent the engines, as they were dwarfed in perspective by the camera, and the massive character of the engines does not appear to advantage in the print. In this case the condensing apparatus is of the horizontal jet principle of construction.

The Photo-print No. 157 shows the fan shaft rope pulley in the foreground, and the steam engines in the background. The rope drum on the engine shaft is about $2\frac{1}{2}$ times larger than the fan shaft rope pulley.

In this print (157) an example of rope driving can be clearly seen. The advantages of the ropes are very great, apart from providing a means of regulating the velocities of the engines and the fan. As a buffer, or elastic medium between the engines and the fan, the ropes are an important factor to ensure smoothness of working of engines and fan, the avoidance of knock, and heating of bearings. An additional advantage is the scope afforded in varying the relative velocities of the engines and fan as the diameters of the rope drums can be modified, if required, with little trouble. We desire it to be clearly understood that we can supply engines and fan coupled "direct" without rope or belt driving, to work as smoothly as it is possible for machinery of this kind to be made to work. Our previous remarks apply chiefly to the heavier duties of fans and engines.

An example of a heavy duty fan engine (directly driven fan) is shown by print No. 97, which represents a tandem compound steam engine, which has for about ten years worked most successfully. This engine is not in duplicate. We, however, invariably recommend engines in duplicate under similar circumstances. The Fan is 35 feet diameter of our improved Guibal type, taking in the air on both sides. It has our patent anti-vibration shutter, and our improved form of the "gradually expanding passage" for the air from the fan.

As proof, however, of the advantages of rope driving for similar and heavier duties we may state that a large Colliery Company, to whom we supplied a fan and engines similar in form and dimensions to the above (No. 97), have ordered four rope driven fans subsequently from us, of equal and still greater power. The Company referred to prefer our rope driven fans of the "Indestructible" type to the Guibal directly driven by the engines.

WE have received the following letter with reference to the working of Ventilating Machinery of the "Indestructible" type. This machinery has been in operation about ten years.

The fan was one of the earliest we constructed on this principle; for this reason the letter appears herein.

The letter came to us in the ordinary way of our business, and was not written as a testimonial to the quality of our machinery.

"*April* 17*th*, 1901.

"MESSRS. WALKER BROTHERS,
"WIGAN.

"DEAR SIRS,

"I have now pleasure in enclosing tracing copies of Diagram taken from the Compound Fan Engine, which I "trust you will find in order. The total Ind. H.P. I make 290, which with 292,000 cubic feet per minute and 4½" W.G. "shows a useful effect of over 71%. This seems almost too good, but the air measurements and Water Gauge "are carefully taken, with no desire to show more than actual results, and it must be borne in mind that great attention "has been paid to the condition of the air-ways, and the distribution of the air underground. The air-ways are large "and exceptionally numerous, and splitting is resorted to for all it is worth. The ventilation recorded is that obtained "every day. The Fan has given the utmost satisfaction from the first, and has not cost a penny in repairs. The "Engines, after renewing the original fan-bearing with Phosphor Bronze, have also done good work, with almost no "outlay for repairs, and the Compound Engine often works 10 to 12 months at 65 revolutions (or 130 Fan) and "say 40 at nights, without stopping for three minutes, not even to fill the crank pin lubricator.

"Yours faithfully,

"*Manager.*"

(The original Letter can be seen on application.—W. BROS.)

SPECIFICATION

OF

"WALKER'S PATENT VENTILATING FAN."

"INDESTRUCTIBLE" TYPE.

The proposed Fan to be constructed to our customary practice and patented designs, in combination with our Anti-Vibration Shutter.

The Fan to be diameter.

GENERAL DESCRIPTION OF THE WALKER FAN.

This Fan is constructed of iron and steel only.

The Fan proper is built upon a central supporting wrought iron shaft.

The Fan, with its shaft, revolves in suitable bearings.

The Fan is designed with the object of admitting the air equally on both its sides, so that the Fan may work in equilibrio—side pressure and friction thus being avoided.

The Fan is intended to effect the required result by working at a moderate velocity of the shaft on its bearings.

Unnecessarily large dimensions of the Fan, on the one hand, and excessive velocities with unduly small diameters, on the other, are objectionable. The ample dimensions of the Walker Fan afford sufficient air-way space to both sides of the Fan. Undue friction of the air on passing into the Fan is thus avoided.

THE MODE OF CONSTRUCTION OF THE FAN.

The Fan is supported on its central shaft by two massive circular cast iron centres, or bosses, with extended flanges. The bosses are accurately bored where they fit on the shaft.

There are two steel discs of considerable diameter placed on the shaft between the two cast iron bosses. These discs are bored where they fit on the shaft.

Between the two discs wrought iron arms of ample strength are fixed, and extend outwards almost to the periphery of the Fan.

These arms support the iron vanes, which are attached thereto, and to the steel discs, by angle irons, rivets, etc.

The cast iron bosses, the steel discs, and the arms are firmly held and tightly gripped together by screw bolts, which are turned and made to fit into rymered holes.

By this mode of construction the whole structure of the Fan becomes one solid machine, resting with equal balance on the central supporting shaft. Suitable means are provided for keying the Fan to the shaft.

The pedestals or plummer-blocks for supporting the Fan shaft are of proper design and number for that purpose.

These pedestals rest upon girders, etc., of cast iron, placed at the two inlets to the Fan chambers.

Our Walker Anti-Vibration Shutter is provided with the Fan and is of suitable dimensions for the required duty.

The purpose of this Shutter is to minimise vibration, by the *gradual* unloading of each vane, as the air is discharged from the Fan to the external atmosphere by the centrifugal force put into the Fan by the action of the steam engine.

The foregoing description of the Fan, and its accompanying details, represents that which we now propose to supply in answer to your present enquiry. The whole of the machinery to be constructed to our customary practice, together with such modifications as our experience may suggest, at our discretion, as being improvements thereto.

The Rope Pulley on the Fan Shaft.

This Pulley to be turned and grooved on the rim for ropes. We supply these ropes and splice them together before being put to work.

Holding down bolts for the fixed details of the Fan. We supply the screwed ends of the bolts, with the necessary nuts and washers.

The machinery to be delivered on trucks per rail at your Colliery, or as near thereto as the rails extend. We provide the necessary skilled engineering assistance to superintend the erection of the machinery. We provide no other labour.

You supply the necessary lifting tackle and the unskilled labour to assist us in the erection of the machinery.

All masonry, brickwork, carpenters' work, etc., to be provided by you.

WALKER BROTHERS.

N.B.—The term "INDESTRUCTIBLE" denotes strength and is not a guarantee.

"THE ENGINEER," July 15th, 1898.

VENTILATING ENGINES, GARSWOOD HALL COLLIERIES.

"The illustration on page 60 represents a pair of horizontal engines which form part of an installation of ventilating machinery erected at the Collieries of the Garswood Hall Collieries Company, Bryun, near Wigan. This machinery was supplied by Messrs. Walker Brothers, of Pagefield Ironworks, Wigan. The installation is unique in its character, inasmuch as it is probably the most powerful of its kind in the United Kingdom, if not in any mining district in the world; the ventilating capacity of the fan and engines being 500,000 cubic feet of air per minute, with 6in. water guage. The engines are of the twin, or side-by-side, compound type, with a high-pressure cylinder 26in. diameter, and a low-pressure cylinder 48in. diameter by 5ft. stroke. The steam pressure is 100 lb. per square inch. The valves of the cylinders are of the simple slide type, with the addition of Meyer's expansion valves—variable by hand whilst the engines are at work—not only to the high-pressure cylinder, but the low pressure-cylinder also, as the gradually increasing demands upon the ventilating machinery necessitate an alteration of the cut-off from time to time in both steam cylinders, as it is desirable that the power derived from each of the engines should be as far as is possible equal to that of the other.

Whilst engines with valves of the Corliss and other types of valve gearing are extensively manufactured by this firm, still in the case of fan engines slide valves are preferred on account of their simplicity. In ventilating machinery for collieries, which has to run continuously night and day all the year round, with the exception of perhaps a few hours' stoppage on Sunday mornings—and this not in all cases—it is imperative to have the valve and other gearing as simple as possible, consistently with economical steam consumption, and with the minimum liability to derangement and break down. For these reasons Messrs. Walker prefer valves on the slide principle for fan engines. The steam and exhaust pipes are so arranged that the engines can work either as a pair or separately, all that is necessary to effect this being the opening or closing of one or two valves and the removal of the connecting rod. In the case of the low-pressure engine, if this be required to work alone, then the steam has to pass through a reducing valve, which is provided with a safety valve to prevent the possibility of the steam entering the low-pressure cylinder at the full boiler pressure. The rope pulley fly-wheel is 24ft. in diameter, about 28 tons in weight, and is grooved for eighteen ropes, $1\frac{3}{4}$in. diameter. The condensing apparatus is of the vertical jet type. The air pump is worked from a trail shaft connected by means of a drag link with the crank pin on the low-pressure side. This condenser is not only connected with the low-pressure cylinder as in the ordinary conditions of working, but when the high-pressure engine is required to work alone it condenses the steam from this engine also.

The ventilating fan is of the Walker 'Indestructible' type, the design of which is the outcome of the nearly thirty years' experience which this firm has had in the construction of colliery ventilating machinery, during which time, we understand, they have supplied fans having an aggregate exhausting capacity of about forty millions cubic feet of air per minute. As already stated the duty required from the installation of ventilating machinery we are now describing, is 500,000 cubic feet of air per minute with a water guage of 6in. This machinery has, however, a margin of power beyond this. The fan is 30ft. in diameter, and 9ft. wide across the vanes. The pulley upon the fan shaft is 11ft. diameter, and grooved, as in the case of the fly-wheel drum, for eighteen ropes $1\frac{3}{4}$in. diameter.

It may be stated that Messrs. Walker construct fans for moderate duties directly driven by the engines, without rope or belt gearing, but their experience for the larger and heavier duties now required at collieries has convinced them that for permanent economy in fuel, lubrication, wear and tear; and freedom from breakdowns, the application of rope gearing is the best mode of driving fans.

Moderate velocities of engines and fans they regard as essential for safe and economical working; but under ordinary circumstances, and, indeed, for the heaviest duties, the fan may be made to run with equal safety at two-and-a-half to three times the velocity of the engines, the comparison being made between the fan shaft and the crank shaft as to the number of revolutions per minute. The fan is called 'Indestructible' by Messrs. Walker, owing to its strength. Their experience has taught them that freedom from stoppage for repairs in the working of colliery ventilating machinery is the chief object to be attained. Economy in steam consumption and general wear and tear rank almost equally high. In former years these points were regarded as of less consideration. Now the indicator diagrams are criticised as on board ship. It must be remembered, however, that the fuel consumed for steam purposes at collieries ordinarily is refuse, and that which usually is not put on the market.

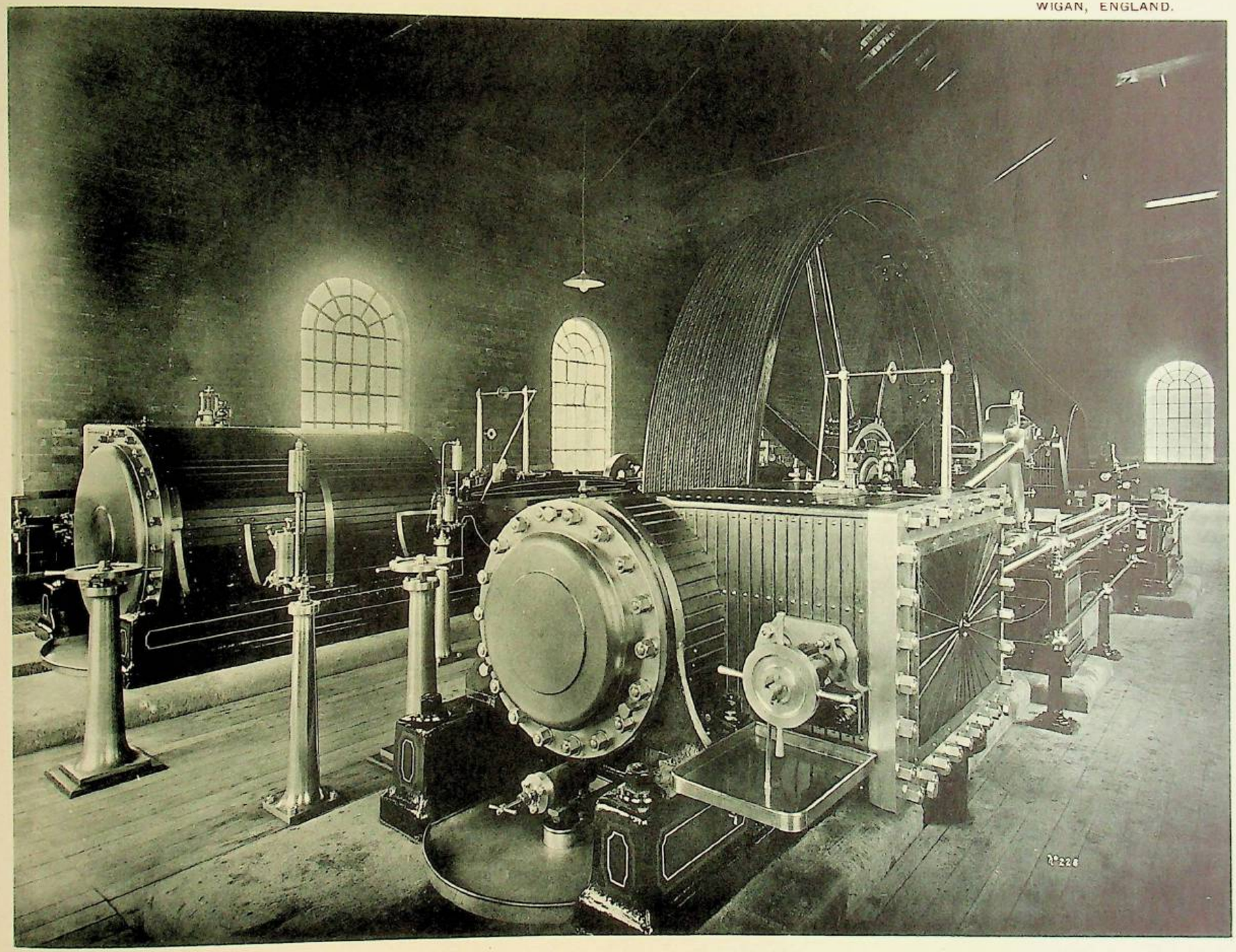
Notwithstanding this, the rule rather than the exception at English collieries now is to have engines of the highest class, compound and condensing, with steam boilers of equal quality. Hence the slur which was formerly cast on colliery owners of 'wasting the national fuel resources' has lost its foundation in fact. The conditions of coal consumption at collieries have completely changed from what they were formerly; and no class of steam users display more keenness as to economy in this respect than British colliery owners do at the present time. The ventilating machinery here illustrated was designed and constructed to the order of the Garswood Hall Collieries Company in this spirit, and with a chief regard to endurance and permanent economy in working. Considering that a colliery fan runs 365 days and nights in the year, too great attention to perfecting engines and fans in general design and detail can scarcely be exercised by the engineer; and any extra first cost incurred in laying down machinery of the highest class is quickly recouped by the greater economy in working."

WALKER BROTHERS,
ENGINEERS.

COLLIERY VENTILATING MACHINERY.

WALKERS' PATENT.

PAGEFIELD IRONWORKS,
WIGAN, ENGLAND.



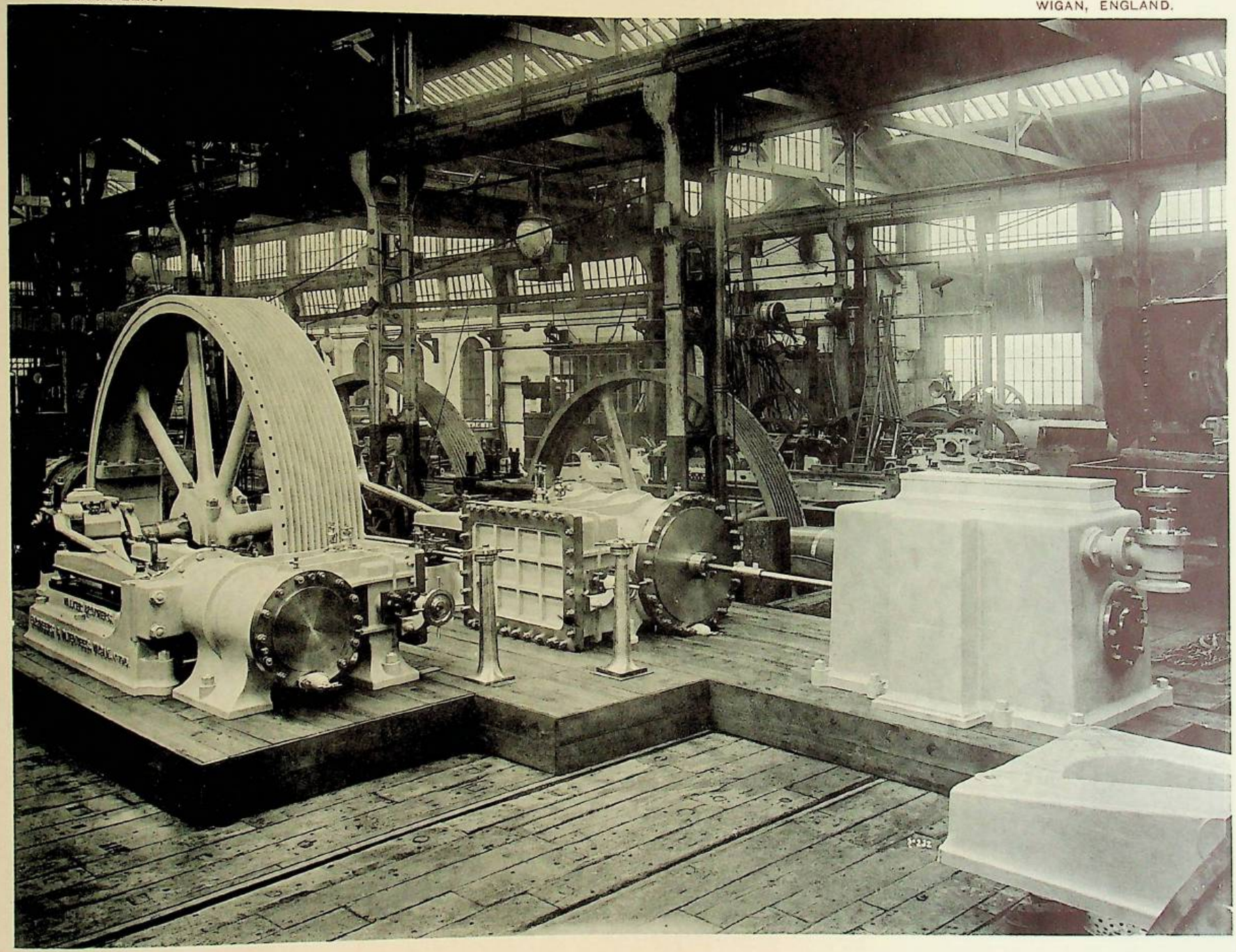
The Photo-print No. 228 shows large Engines supplied to a Lancashire Colliery Company, to drive by rope gearing a Fan, with a ventilating capacity of 500,000 cubic feet of air per minute and 6 inches water guage. The Fan is of our "Indestructible" type. The Engines have steam condensing apparatus. [PHOTOGRAPHED AT THE COLLIERY.]

COLLIERY VENTILATING MACHINERY.

WALKER BROTHERS,
ENGINEERS.

WALKERS' PATENT.

PAGEFIELD IRONWORKS,
WIGAN, ENGLAND.



The Photo-print No. 232 represents a modern type of our Compound Condensing Steam Engines for driving a Ventilating Fan (with rope gearing).

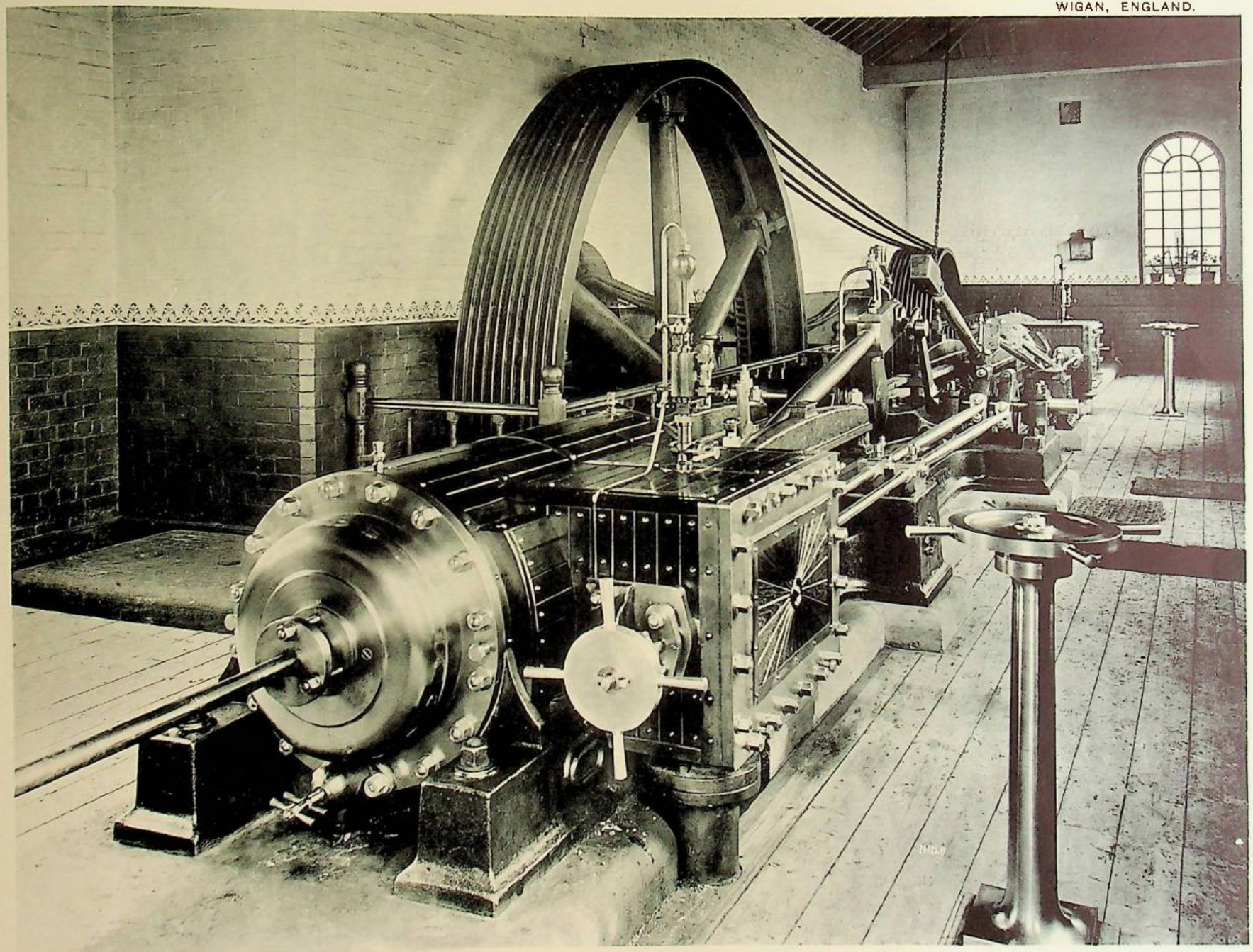
[PHOTOGRAPHED AT PAGEFIELD IRONWORKS.]

COLLIERY VENTILATING MACHINERY.

WALKER BROTHERS.
ENGINEERS.

WALKERS' PATENT.

PAGEFIELD IRONWORKS,
WIGAN, ENGLAND.



The photo-print No. 128 represents Steam Engines, in duplicate for driving by rope gearing a Fan of our "Indestructible" type, as erected at a Colliery. One of the Engines is condensing, the other non-condensing. The engines work, as required, alternately. The crank shaft is common to both engines. The valves on the cylinders are on the slide principle, with expansion valves variable by hand (Meyer's principle).

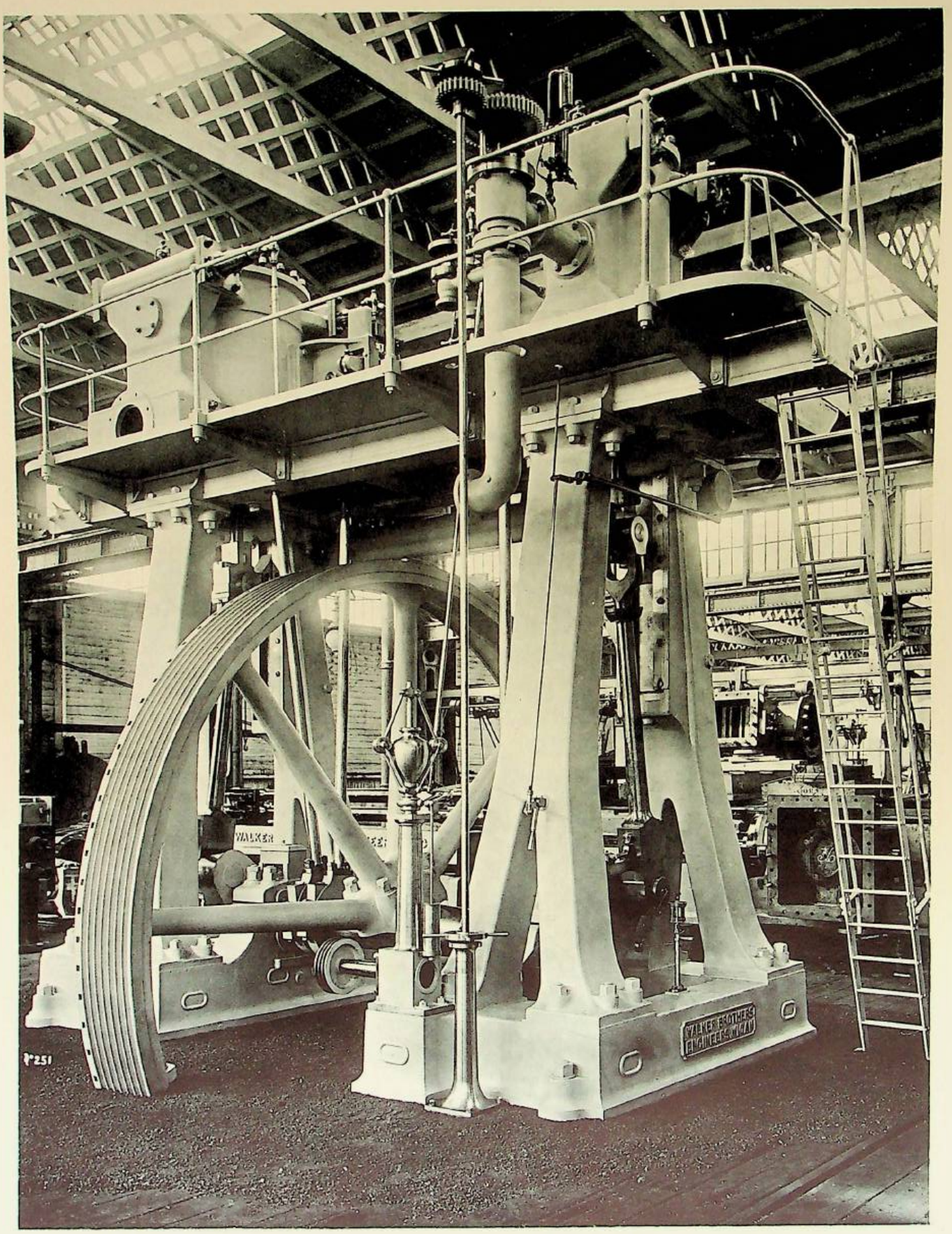
[PHOTOGRAPHED AT THE COLLIERY WHEN COMPLETE.]

COLLIERY VENTILATING MACHINERY.

WALKER BROTHERS,
ENGINEERS.

WALKERS' PATENT.

PAGEFIELD IRONWORKS,
WIGAN, ENGLAND.



The Photo-prints No. 251 and 252 represent a pair of Vertical Engines of the compound type for driving a Ventilating Fan (with rope gearing). The valves on the steam cylinders are on the Corliss principle.

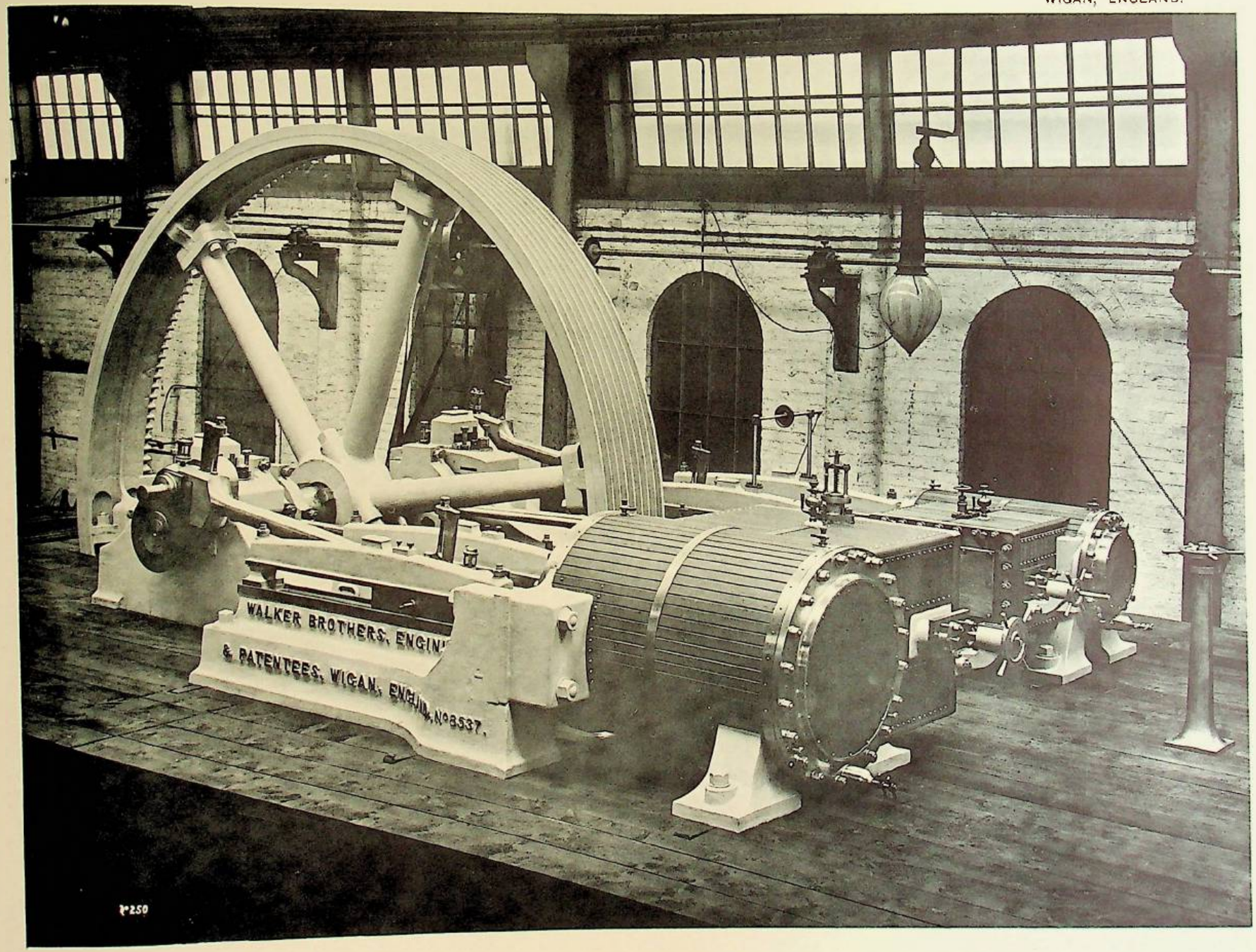
[PHOTOGRAPHED AT PAGEFIELD IRONWORKS.]

COLLIERY VENTILATING MACHINERY.

WALKER BROTHERS,
ENGINEERS.

WALKERS' PATENT.

PAGEFIELD IRONWORKS,
WIGAN, ENGLAND.



The Photo-prints No. 249 and 250 represent a pair of Compound Condensing Engines of modern form, for driving a Ventilating Fan (with rope gearing).

[PHOTOGRAPHED AT PAGEFIELD IRONWORKS.]

The names of the Colliery Companies to whom we have supplied the "Indestructible" Fans.

We give on the following pages the names of the Colliery and other Companies to whom we have supplied our "Indestructible" Fans.

Those Colliery Companies to whom we have supplied our Guibal Fans do not appear on the list of names herein.

The "Indestructible" Fan can be driven from the Engine, either by ropes or leather belts, or be directly attached to the Engine. The great majority of the Fans referred to herein are rope-driven by the Engines.

The name, "Indestructible," is used simply to denote the strength and endurance of the Fan, and must not be considered as a guarantee.

We have several hundred installations of Colliery Ventilating Machinery at work in the United Kingdom, and these include the most powerful machinery of the kind in existence.

We believe the Ventilating Machinery represented by the list herewith to be unique in the power of the individual installations, and in the aggregate capacity also. We also consider the names of the Colliery Companies, who have honoured us with their confidence, are a guarantee of the merits of our machinery, and we trust a recommendation to your consideration of our claims also.

N.B.—The volumes of air and water gauges mentioned in the lists are approximate only.

ENGINEERS WALKER BROTHERS WIGAN

NAME OF FIRM.		AIR VOLUME. Cubic feet per minute.	WATER GAUGE.	TYPE OF ENGINE.
			Inches.	
The Powell Duffryn Steam Coal Co.	S. Wales	150,000	3	Twin Compound
Ditto	do.	300,000	5	Ditto
Ditto	do.	350,000	6	Vertical-Corliss (Compound)
Ditto	do.	80,000	2	Tandem Compound
Ditto	do.	200,000	4	——
Ditto	do.	500,000	6	Vertical-Corliss (Compound)
Ditto	do.	150,000	3	——
Powell's Tillery Co.	Abertillery	300,000	4	Non-compound
Messrs. Richard Evans & Co.	Haydock, Lancs.	200,000	7·5	Twin Compound
Ditto	do.	300,000	5	Ditto
Ditto	do.	400,000	6	Ditto
Ditto	do.	300,000	5	Ditto
Pearson & Knowles C. and I. Co.	Wigan	300,000	5	Ditto
Ditto	do.	300,000	4	Ditto
Ditto	do.	50,000	3	Ditto
Messrs. Fletcher, Burrows & Co.	Atherton	250,000	5·25	Non-compound
Garswood Hall Collieries Co.	do.	500,000	6	Twin Compound
Ditto	do.	150,000	4	Non-compound
Crawshay Brothers, Limited	Merthyr Tydfil	140,000	7	Twin Compound

* THESE FANS ARE NOW IN COURSE OF CONSTRUCTION.

ENGINEERS WALKER BROTHERS WIGAN

NAME OF FIRM.		AIR VOLUME. Cubic feet per minute.	WATER GAUGE.	TYPE OF ENGINE.
			Inches.	
Hucknall Colliery Co.	Nottingham	50,000	10	Non-compound Erected in Mine
Waynes Merthyr Co.	Cwmtillery	200,000	4	——
Wigan Coal and Iron Co.	Wigan	353,000	6	Twin Compound
Ditto	do.	200,000	3·5	Ditto
Messrs. J. & R. Stone	do.	300,000	6	Ditto
Grassmoor Co., Limited....	Chesterfield	250,000	3	Ditto
Thomas Fletcher & Sons, Limited	Bolton-le-Moors	300,000	6	Ditto
Messrs. W. & J. Turner	do.	300,000	5	Ditto
Messrs. J. Speakman & Sons	Leigh	330,000	5	Ditto
Moss Hall Coal Co.	Wigan	500,000	6	Ditto
Dinas Main Coal Co.	Cardiff	400,000	5	Ditto
Bwllfa and Merthyr Dare Steam Collieries, Limited	Aberdare	300,000	4	Non-compound
Babbington Coal Co.	Nottingham	70,000	3	Ditto
Ditto	do.	120,000	4	Vertical Engines
Ditto	do.	200,000	4	Non-compound
Douglas Bank Colliery Co.	Wigan	300,000	5·5	Twin Compound
Ditto	do.	60,000	3	Erected in Mine
Messrs. A. Knowles & Sons	Manchester	120,000	3	Non-compound

* THESE FANS ARE NOW IN COURSE OF CONSTRUCTION.

ENGINEERS WALKER BROTHERS WIGAN

NAME OF FIRM.		AIR VOLUME. Cubic feet per minute.	WATER GAUGE.	TYPE OF ENGINE.
			Inches.	
Messrs. A. Knowles & Sons	Manchester	60,000	6	Non-compound
Messrs. G. Hargreaves & Co.	Accrington	170,000	5·9	Twin Compound
Messrs. Lamb & Moore	Wigan	40,000	4·5	Non-compound
Messrs. Crawshaw & Warburton	Dewsbury	200,000	4	Twin Compound
Messrs. Cross, Tetley & Co.	Wigan	400,000	5	Ditto
Sir J. Wolfe Barry, for the Glasgow Central Railway Co.		150,000	—	Tandem Compound
Messrs. J. Lancaster & Co.	Blaina	400,000	5	Twin Compound
Ditto	do.	250,000	4	Ditto
Barrow Hematite Steel Co., Limited	Barnsley	300,000	6	Ditto
Ammanford Colliery Co.	Ammanford	300,000	6	Ditto
Glamorgan Coal Co.	Cardiff	300,000	6	Tandem Compound
Messrs. Partridge, Jones & Co.	Pontypool	300,000	5	Ditto
Ditto	do.	250,000	5	Twin Compound
Ditto	do.	300,000	5	Ditto
Ackton Hall Colliery Co.....	Featherstone	300,000	3	Ditto
Shireoaks Colliery Co.	Worksop	250,000	3	Non-compound
Harton Coal Co., Whitburn Colliery	South Shields	300,000	5	Twin Compound
Ditto	do.	300,000	5	Ditto
Ditto	do.	250,000	6·6	Ditto
Ditto ...	do.	350,000	5	Ditto
Ditto				

SIR LINDSAY WOOD, BART., *Managing Director.*
GEORGE MAY, ESQ., *Chief Viewer.*

* THESE FANS ARE NOW IN COURSE OF CONSTRUCTION.

ENGINEERS WALKER BROTHERS WIGAN

NAME OF FIRM.		AIR VOLUME. Cubic feet per minute.	WATER GAUGE.	TYPE OF ENGINE.
			Inches.	
Stafford Coal and Iron Co.	Stoke-on-Trent	200,000	4	Tandem Compound
Messrs. H. Warrington & Son	do.	200,000	4	Twin Compound
The New Russia Co., Limited	Russia	300,000	3	Ditto
Ditto	do.	300,000	3	Ditto
Ditto	do	300,000	3	Ditto
Ditto	do.	100,000	3	Non-compound
Cardiff Steam Coal Co.	Cardiff	100,000	3	Twin Compound
Sutton Heath and Lea Green Collieries	St. Helens	300,000	4·5	Ditto
Messrs. Hy. Briggs, Sons & Co., Limited	Normanton	250,000	3	Non-compound
Messrs. Platt Bros. & Co.	Oldham	250,000	6	Twin Compound
North's Navigation Collieries, Limited	Bridgend	300,000	4	Ditto
Ditto	do.	100,000	8	Ditto
Sneyd Collieries, Limited	....	350,000	5	Ditto
Eagle's Bush (Hughes' Vein) Colliery Co.	Neath	60,000	2	Non-compound
Swan Lane Brick and Coal Co.	Wigan	75,000	2	Ditto
J. & G. Joicey & Co.	Newcastle-on-Tyne	220,000	3	Twin Compound
Farrington Coal Co.	Redditch	25,000	1	——
Clifton & Kersley Coal Co.	Manchester	70,000	3	Non-compound
Whitehaven Colliery Co.	Whitehaven	200,000	6	Ditto
Ditto	do. ...	150,000	8 to 9	Twin Compound

* THESE FANS ARE NOW IN COURSE OF CONSTRUCTION.

ENGINEERS WALKER BROTHERS WIGAN

NAME OF FIRM.		AIR VOLUME. Cubic feet per minute.	WATER GAUGE.	TYPE OF ENGINE.
			Inches.	
White Moss Colliery Co.	Wigan	150,000	4	——
W. Ramsden & Sons	Tyldesley	200,000	4	Non-compound
South Cambria Collieries Syndicate, Ltd.	Cardiff	100,000	3	Ditto
The Duffryn Rhondda Co.	Port Talbot	40,000	2·5	Non-compound
The Nailstone Colliery Co.	Leicester	60,000	3	Ditto
The Scottish Australian Mining Co., Limited	Australia	300,000	3	Twin Compound
Messrs. James Oakes & Co.	Alfreton	150,000	3	Non-compound
Sheffield Coal Co.....	Sheffield	30,000	6	Erected in Mine
Midland Railway Co.	St. Pancras Tunnel	150,000	—	Gas Engine
Assam Railway and Trading Co.	India	60,000	2	Engines in Duplicate
Ditto	do.	100,000	2	Ditto
Messrs. Bridgewater Trustees	Manchester	150,000	3	Non-compound
Ditto	do.	200,000	3	Ditto
Ditto	do.	300,000	5	Twin Compound
Astley & Tyldesley Coal Co.	do.	300,000	4	Ditto
Ditto	do.	400,000	5	——
Messrs. Newton, Chambers & Co.	Sheffield	150,000	5·6	Twin Compound
Rhymney Iron Co.	Rhymney	200,000	4	Tandem Compound

* THESE FANS ARE NOW IN COURSE OF CONSTRUCTION.

ENGINEERS WALKER BROTHERS WIGAN

NAME OF FIRM.		AIR VOLUME. Cubic feet per minute.	WATER GAUGE.	TYPE OF ENGINE.
			Inches.	
Griff Colliery Co.	Nuneaton	60,000	2	——
Canada N.W. Coal and Lumber Syndicate	Canmore	35,000	3	Non-compound
Southern Coal Co. of New South Wales	....	200,000	3	Tandem Compound
Hill's Plymouth Co.	Merthyr	150,000	3	Ditto
Messrs. J. Critchley & Sons	Batley	150,000	3	Non-compound
Metropolitan Coal Co. of Sydney	Australia	400,000	4	Tandem Compound
Messrs. J. & W. Stone	Blaina	80,000	3	Non-compound
Coalbrookvale Colliery Co.	South Wales	200,000	4·5	Ditto
Messrs. J. Vipond & Co.	Pontypool	100,000	3·5	——
Messrs. Morris & Shaw, Limited	Tamworth	150,000	3	Non-compound
Rylands Main Coal Co.	Barnsley	60,000	3	Ditto
Earl Dudley	Dudley	60,000	3	Ditto
New Hucknall Colliery Co.	Mansfield	218,000	7·7	Ditto
Bolsover Colliery Co.	Chesterfield	150,000	3	——
Ditto	do.	60,000	3	Twin Compound
Ditto	do.	250,000	4	Ditto
Nunnery Colliery Co.	Sheffield	—	—	Tandem Compound
Universal Steam Coal Co.	Cardiff	400,000	4	Twin Compound
Collins Green Colliery Co.	Earlestown	400,000	5	Ditto

* These Fans are now in course of construction.

ENGINEERS WALKER BROTHERS WIGAN

NAME OF FIRM.		AIR VOLUME. Cubic feet per minute.	WATER GAUGE.	TYPE OF ENGINE.
			Inches.	
Wallsend & Hebburn Coal Co.	Newcastle-on-Tyne	200,000	4	Non-compound
The Clay Cross Co.	Chesterfield	150,000	3	Ditto
Sutton Colliery Co.	Nottingham	300,000	4	Tandem Compound
Crigglestone Coal Co.	Wakefield	100,000	3	——
Midland Coal, Coke and Iron Co.	Apedale	200,000	3	——
Sydney Harbour Collieries, Limited	Australia	400,000	4	Twin Compound
The Guanta Co., Limited	Venezuela	60,000	3	Ditto
Fife Coal Co.	Fifeshire	150,000	2	Non-compound
Ditto	do.	150,000	2	Ditto
Chatterley Whitfield Colliery	Stoke-on-Trent	200,000	4	Ditto
The Ebbw Vale Steel, Iron and Coal Co.	Monmouth	350,000	4	Twin Compound
Shelton Iron, Steel and Coal Co.	Stoke-on-Trent	100,000	8	Non-compound
Backworth Colliery Co., Limited	Newcastle-on-Tyne	200,000	3	Ditto
Mersey Railway Co.	Liverpool	150,000	—	Tandem Compound
Ditto	Liverpool and Birkenhead	(2) 90,000	·5 to ·6	——
Aberdare Merthyr Co.	Hirwain	100,000	3	Non-compound
Rothervale Colliery Co.	Rotherham	300,000	3	——
Messrs. Brunner, Mond & Co.	Northwich	Chemical--Process		Non-compound
Bridgeness Coal Co.	Bo'ness, N.B.	50,000	3	——
Ditto	do.	180,000	3·5	Twin Compound

* THESE FANS ARE NOW IN COURSE OF CONSTRUCTION.

ENGINEERS WALKER BROTHERS WIGAN

NAME OF FIRM.		AIR VOLUME. Cubic feet per minute.	WATER GAUGE.	TYPE OF ENGINE.
			Inches.	
Messrs. William Baird & Co.	Glasgow	25,000	1	Non-compound
Ditto	do.	25,000	1	Ditto
Ditto	do.	30,000	1	Ditto
Ditto	do.	70,000	2·5	Ditto
Ditto	do.	100,000	4	Ditto
Whitecross Co.	St. Helens	35,000	3	——
Main Colliery Co.	Neath	50,000	3	——
Lewis Merthyr Colliery Co.	Hafod	50,000	3	——
Granville Colliery Co.	Burton	150,000	5	——
The Indian State Railways	....	100,000	1·5	Tandem Compound
Park Hall Colliery Co.	Longton	80,000	1	Non-compound
New Limehurst Colliery Co.	Ashton-under-Lyne	125,000	4	Ditto
Earl Bradford	Bolton	100,000	4·5	Tandem Compound
Worsley Mesnes Colliery Co.	Wigan	200,000	4	Ditto
Messrs. R. & J. Durie	Tranent, N.B.	100,000	1·5	Non-compound
Eccleston Hall Colliery Co.	Prescot	60,000	3	Ditto
The Wemyss Coal Co.	West Wemyss, Fife	70,000	4	Ditto
Messrs. Pease & Partners, Limited	Crook, by Darlington	70,000	3	Ditto
Messrs. L. Guéret, Limited	Swansea	40,000	3	Ditto

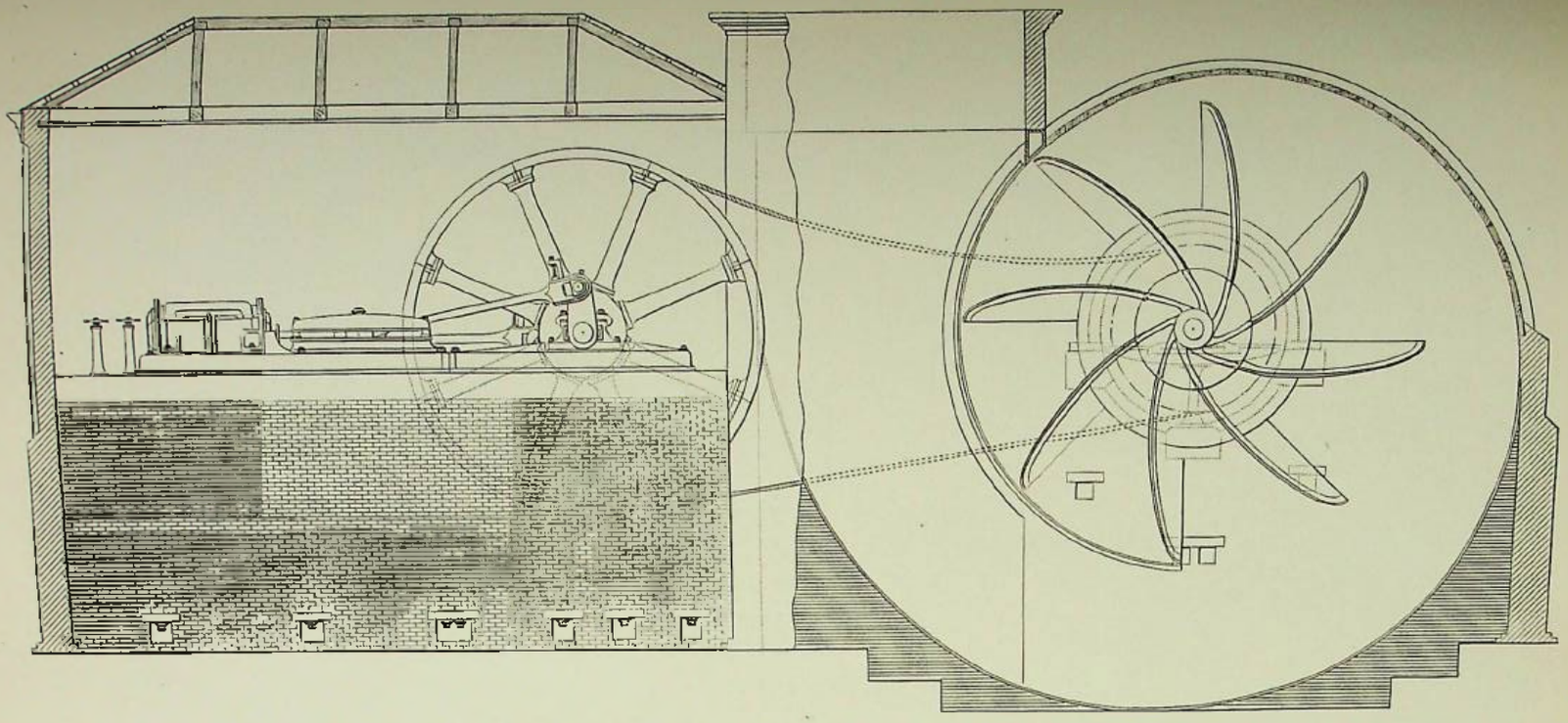
* THESE FANS ARE NOW IN COURSE OF CONSTRUCTION.

ENGINEERS WALKER BROTHERS WIGAN

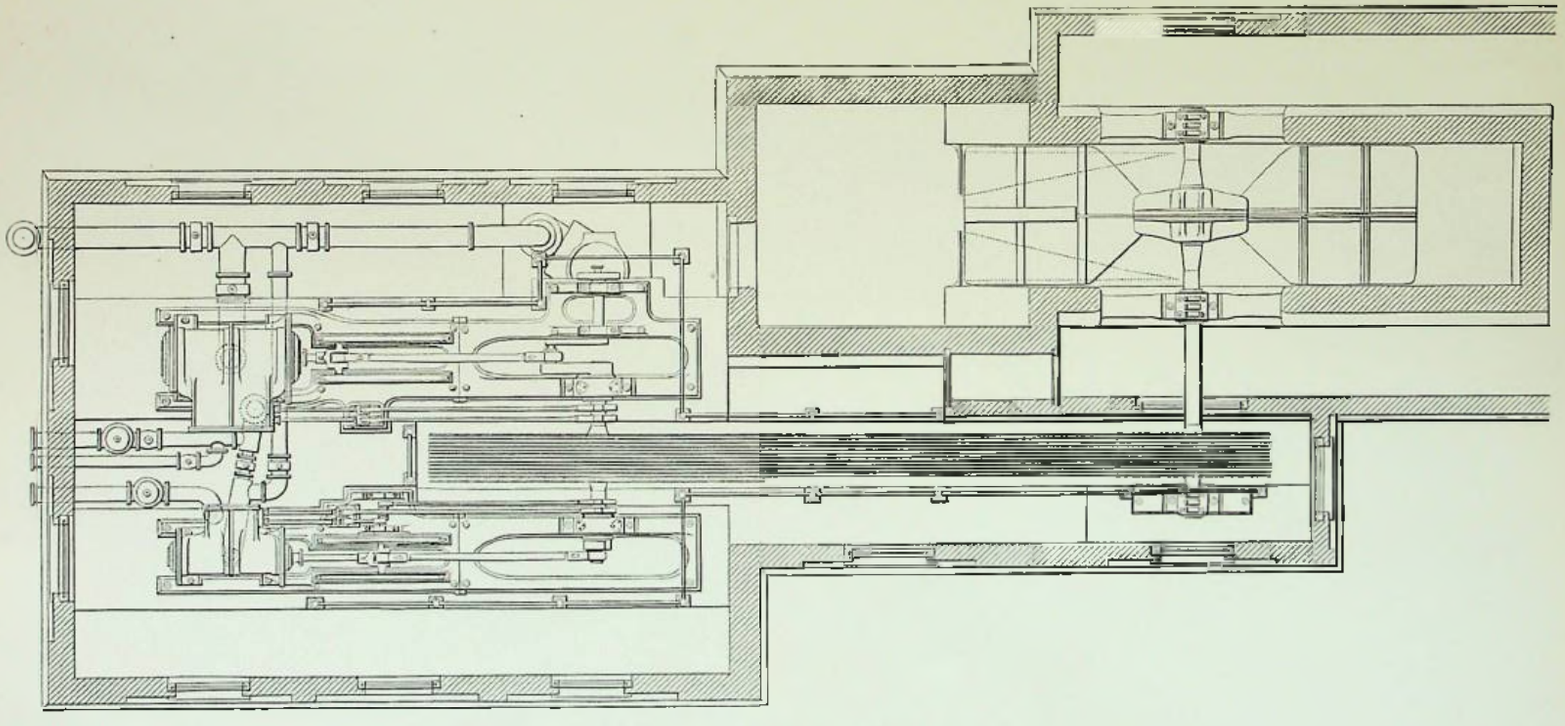
NAME OF FIRM.		AIR VOLUME. Cubic feet per minute.	WATER GAUGE. Inches.	TYPE OF ENGINE.
Messrs. G. S. Yuill & Co.	London (for Australia)	100,000	2·5	Non-compound
Lord Lathom	Skelmersdale	125,000	3	Ditto
Ellerbeck Colliery Co., Limited...	Wigan	160,000	3	Ditto
Lothian Coal Co., Limited	Rosewell	150,000	3	Ditto
South Leicestershire Colliery Co.	Leicester	80,000	3·5	——
Messrs. Foster, Williams & Co.....	Skelmersdale	150,000	2	Tandem Compound
The Acadia Coal Co.	Nova Scotia	120,000	4·5	Twin Compound
The Inter-colonial Coal Co.	do.	120,000	4·5	Ditto
Messrs. P. W. Pickup, Limited....	Rishton	120,000	2	——
Mount Pleasant Coal and Iron Mining Co.	Sydney	100,000	2	Non-compound
Duncan, Fox & Co.	Liverpool	80,000	6	Twin Compound
Soemalata Mining Co.	Soemalata	20,000	1·5	——
Bolckow, Vaughan & Co., Limited ..	Middlesbrough ...	200,000	2 to 3	——
Ditto ...	do ...	400,000	4	Twin Compound
West Hallam Colliery Co., Limited	Ilkeston	250,000	3	Ditto
Cwmaman Coal Co., Limited	Cardiff	200,000	4	——
East India Railway Co	.. ..	400,000	3	Twin Compound
Burnyeat, Brown & Co., Limited... ...	Treorchy	250,000	5	Ditto
Inverness and Richmond Railway Co. ...	Broad Cove ...	250,000	2	Non-compound
Durban Collieries Co., Limited	Natal	200,000	3	Ditto

* THESE FANS ARE NOW IN COURSE OF CONSTRUCTION.

"WALKER" PATENT "INDESTRUCTIBLE" VENTILATING FAN,
ROPE-DRIVEN WITH COMPOUND ENGINES.



SECTIONAL ELEVATION.



SECTIONAL PLAN.

THE WALKER PATENT "INDESTRUCTIBLE" VENTILATING FAN AND ENGINES,

AS ERECTED AT THE PARK COLLIERIES, GARSWOOD;

THEIR

Construction, Arrangement, and Efficiency.

By Mr. CHARLES H. HIGSON.

Read before the Manchester Geological Society, January 12th, 1894.

(Trans. Manchester Geol. Soc., Part XV., Vol. XXII.)

[Mr. Higson's Paper contains a description of the Walker Fan and the Engines.]

"The Walker 'Indestructible' Ventilating Fan and Engines were introduced some seven years ago by Messrs. Walker Bros., of the Pagefield Ironworks, Wigan, and a ventilating plant of this description having been erected at Messrs. J. & R. Stones' collieries at Garswood, of which I have charge, it has been suggested to me that a description of its construction, arrangement, and efficiency would be acceptable to the members of this Society.

In designing this machinery endeavour has been made to produce an arrangement which, while obtaining a high degree of economy and efficiency, should possess freedom from liability to break down, and also sufficient simplicity in its working parts to bring it within the comprehension of the every-day colliery engineman. With this view the engines have been made large enough to perform their duty at a moderate piston speed, and all complicated valve gearing has been avoided. Experience in the construction of engines driving ventilating machinery, and indeed in colliery engines generally, has shown the advantage of moderate speeds. These engines were designed for a speed of 50 revolutions per minute. This gives a piston speed of 400 feet per minute, which is very moderate when compared with the performances of many engines driving mills; but it is found that the destructive effect lies not so much in the speed at which the piston travels as in the frequency of its change of direction, and that a speed of 50 revolutions per minute is the most advantageous when dealing with engines of the class and size herein referred to.

In the case of mill engines it is usual to run them at much higher speeds; but the difference between these engines and those driving ventilating machinery is that the former work with the advantage of the intervals of meal-times and stoppages during the night and at week-ends, but with fan engines the stoppage is limited, as a rule, to a very brief interval on Sunday mornings, and in some cases even this is not permissible.

Taking the hours worked during a week, mill engines run only one-third the time of fan engines; or, in other words, each year the work done by ventilating engines represents three years' work as compared with mill engines.

The engines are of the twin or side-by-side compound condensing type—that is to say, there is a crank at each end of the crank shaft, one crank being actuated by the high-pressure piston and the other by the low-pressure piston, the driving pulley being placed midway between the two cranks.

The stroke of each cylinder is 4 feet. The diameter of the high pressure cylinder is 22 inches, and of the low-pressure cylinder 38 inches.

The valves are ordinary slide valves, an adjustable cut-off valve being fitted to the high-pressure cylinder. The cut-off valve can be regulated while the engines are running, and it is intended that the stop-valve should remain at all times wide open, the speed being controlled by the cut-off valve.

A warming valve admits live steam to the low-pressure cylinder to warm it before starting, and to start the engines when the high-pressure crank is on the dead centre.

In Messrs. Walkers' more recent engines, adjustable cut-off valves are fitted to both cylinders. This enables the load to be equally divided between the high and low pressure cylinders at all speeds, to meet the varying duty required from ventilating machinery, as in the case of new mines opening out.

By means of a system of valves in the exhaust pipes, either engine may be disconnected and the remaining engine may be worked alone, either condensing or otherwise, and is sufficiently large to develop almost the full duty of the fan when so doing.

A separate steam stop-valve is provided to admit live steam direct to the low-pressure cylinder when working alone, and a combined reducing and safety valve reduces the steam pressure in proportion to the increased diameter of the piston, and prevents the accumulation of dangerous pressure in the pipes leading to the low-pressure cylinder.

A three-way valve on the main exhaust pipe, and controlled from the engine-room, enables the man in charge to turn the exhaust steam into the condenser or into the atmosphere, as may be required, whilst the engines are running.

The air pump is worked by a drag-crank from the low-pressure crank pin.

Motion is transmitted to the fan by fifteen cotton ropes, each $1\frac{5}{8}$ in. diameter. The grooved driving pulley is 16 ft. diameter, and the driven pulley on the fan shaft is 7 ft. 6 in. diameter, giving a ratio of one to a little over two.

It is found that these cotton ropes run most satisfactorily at speeds of 3,000 ft. per minute and over, and it is therefore now the practice to increase the diameter of the driving pulley to 20 ft. for engines of this size.

The power which may be safely transmitted by a cotton rope $1\frac{5}{8}$ in. diameter may be taken at about 10-horse power per 1,000 ft. per minute up to 3,000.

In mill practice it is found that the average life of cotton driving ropes when properly treated is about twelve years. The comparatively recent application of these ropes to ventilating machinery renders it impossible to say what their durability is likely to be; but experts say that it will probably exceed that of mill ropes, in consequence of the steady load and freedom from sudden strains.

The method adopted for lubricating the crank pins is a noteworthy feature of the engines.

A cylindrical vessel filled with oil is suspended above the crank pin. A rectangular brass tube passes through the bottom of the vessel and projects above the surface of the oil inside. A number of woollen threads are led from the inside of the vessel through the tube, and are allowed to hang downwards from its end.

The wool becomes saturated with oil by capillary attraction, the flow of oil being regulated by a brass plate inside the tube, which may be caused to compress the wool.

To the end of the connecting rod is attached a brass tongue in such a manner as to come into contact with the saturated wool at each revolution, wiping off a certain quantity of the oil, and conducting it to the crank pin. The tongue is faced with flannel to prevent the oil being thrown off by centrifugal force.

The consumption of oil is 1½ pints per week for each crank pin.

When local circumstances will permit of its adoption the 'twin' arrangement—that is, placing the high and low pressure cylinders side by side—is much superior to the tandem arrangement, in which the cylinders are placed one behind the other.

By the twin system the inconvenience of dead centres is avoided, as live steam can be admitted to the low-pressure cylinder to start the engines when the high-pressure crank is centred. The driving pulley receives a comparatively light impulse at each of four points in the revolution, instead of receiving a heavy impulse at each of two points in the revolution, and greater regularity and evenness in the running of the ropes is thereby secured. The working parts may be lighter and are more evenly balanced, and an accident, for instance, to a crank pin, which could be met by disconnecting the disabled engine and by running the other alone, would, in the case of the tandem engines, lay the fan idle and stop the pits until the damage was repaired.

THE FAN.

The chief points aimed at in designing the 'Indestructible' Fan were (I learn from the makers) to produce a ventilating machine which should obtain a high percentage of useful effect without the great weight, unwieldy dimensions or expensive foundations of the large direct driven fans, and which should at the same time possess the strength, rigidity and durability of the smaller fans, whilst avoiding their high speed and consequent frequently heated bearings.

The construction of the fan which is 24 ft. diameter and 8 ft. wide, and is built up exclusively of iron and steel, is as follows:—

There are two strong cast-iron bosses. These bosses are carefully bored out and made a good fit upon the fan shaft, and are further secured to the shaft by means of steel keys. The bosses extend lengthwise on each side towards the journals, thereby distributing the weight of the fan over a considerable portion of the fan shaft.

Between the bosses are placed two discs of steel, of uniform thickness, bored in the centre to fit the fan shaft.

The bosses, where they come in contact with the discs, are turned on the face.

Each disc is in halves, the joints being placed at right angles to each other. By this arrangement the two discs form one disc of considerable strength, much lighter but stronger than if the disc were in one solid plate.

Between the two discs the iron arms of the fan are fixed 'sandwich-like,' and are gripped tightly by them. These arms extend from near the axis of the fan to its periphery, being supported half-way by the discs.

The two bosses are secured together by means of turned bolts passing into carefully rymered holes; the bolts being lock-nutted, and as these bolts pass through both the discs, the bosses and the fan-arms, the whole structure becomes specially strong.

In the small spaces between the discs which are not filled up by the fan-arms, there are inserted annular plates. The whole portion outside the boss is then securely rivetted together.

Angle irons are rivetted to the fan-arms where they extend beyond the discs; to these angle irons the vanes—eight in number—are firmly secured, the cross section of the arm and vane together being like the letter T, thus forming a beam of great strength and rigidity. The top of the

T representing the vane and the surface pressing against the air. The vanes, which spring tangentially from a small circle concentric with the fan shaft, are curved longitudinally to the arc of a circle of a certain radius, and are cut away from the edge of the inlet to the fan shaft to minimise central resistance.

The main bearings of the fan are placed in the two inlets of the fan chamber, the distance inside the bearings being only 8 feet; the outer bearing being placed just outside the rope pulley upon the fan shaft. The latter bearing is made with adjustable brasses, so that the wear produced by the tension of the ropes may be taken up.

The pedestals are cased all round to prevent access of dust to the bearings.

It is very necessary to minimise the slipping of the air between the sides of the vanes and the walls of the fan chamber as far as practicable. The vanes being strong and of iron cannot be brought close to the walls, as in the event of any side movement of the fan on its bearings the vanes might 'catch' and be injured. This clearence is, therefore, made up by attaching strips of pliable hoop iron to the sides of the vanes.

The method adopted for obtaining constant lubrication of the fan bearings is worthy of notice. An eccentric upon the crank shaft of the engines actuates a small pump which delivers oil from a tank beneath the floor of the engine-room into one fixed high up against the wall. From this latter tank the oil flows by gravity through pipes communicating with each of the fan bearings, and, after lubricating the journals, is collected by cups fixed to the sides of the pedestals and conducted to the lower tank. Here it is filtered by passing through a sheet of copper gauze, and is again pumped into the upper tank. Constant lubrication is thereby secured, the bearings practically running in a bath of oil. **The consumption of oil is four pints per week for the three bearings.**

The Fan is fitted with the Walker Anti-vibration Shutter.

The history of the invention and introduction of this shutter (for which I am indebted to the makers) is very interesting.

About 1886 Messrs. Walker constructed and erected three Guibal fans for ventilating a portion of the Metropolitan and District Underground Railway.

Those who have had experience with Guibal fans will be aware that as each blade or vane passes the lower edge of the shutter a pulsatory action takes place. When the fans above mentioned were set to work the pulsation or vibration of the large volume of air discharged was so great that it caused a corresponding vibration of the window sashes, doors, &c., of the surrounding buildings, and this was so unpleasant that the professional men and others near obtained an injunction against the railway company compelling it to stop one of the fans. The work by this time was out of the makers' hands, and they only casually heard what had taken place, learning, also, that in addition to this injunction another was threatened in the case of the second fan, and that the railway company had thus far escaped the enforcement of this threat by agreeing to run the second fan at a few short stated intervals only during the day.

In considering the case it occurred to the makers to incline the lower edge of the shutter instead of making it parallel with the axis of the fan, by which means it was thought that the waves of air might be broken up or at least reduced. It was, however, ultimately decided to make the shutter like an inverted V, and this was found to be completely successful.

Having thus explained the history of this invention and its utility in removing vibration and consequent noise, we now come to a still more important advantage to be gained by its application. Experience in the working of Guibal fans proves that fan shafts, even though made unusually strong in proportion to the horse-power transmitted through them, frequently break. In Belgium, the birth-place of the Guibal fan, the average life of the shaft is found to be from twelve to fifteen years. The breakage of fan shafts, and the loosening of bolts and rivets in fans generally, are to be attributed to the excessive vibration hitherto inseparable from their working. This vibration is caused by the too abrupt cessation of the delivery of the air from the fan vanes or blades as they pass the opening to the chimney, and for this the shape of the regulating shutter or slide is responsible.

The upper part of this opening, formed by the shutter as hitherto constructed, has a line parallel to the tips of the fan vanes, and as the fan revolves these lines become identical; the delivery of the air is as a consequence abruptly terminated.

Whilst discharging the air, the pressure is against the front of the vane, but immediately the vane enters the fan casing the load upon it is suddenly removed, and the pressure, owing to the vacuum within the casing, is instantaneously reversed, and a rebound upwards of the previously depressed blade takes place. The effect is communicated throughout the whole of the fan and to the shaft also, and as each blade represents a powerful lever, the momentum of the blow or jerk becomes serious on reaching the shaft, and a dangerous tremor or vibration is set up.

As an illustration of the effect of this action let us take the case of a fan constructed strictly on Guibal principles, and upon which experiments were made some time ago. In these experiments readings were taken from a water gauge which was attached to the fan casing at intervals from the centre to the periphery, above the shaft. At the centre the water gauge indicated 3 inches, but near the outer edge or periphery it was half an inch. The fan was 24 feet diameter and ran at 80 revolutions per minute. Taking the average water gauge over the surface of the blades at 1½ inches it would represent a pressure of 7·8 lbs. per square foot, or a total pressure on each blade of nearly 500 lbs. Assuming the centre of the blade to be the centre of the load, the distance from the centre of the load to the centre of the fan shaft, would be, approximately, 9 feet. Taking the work of one day of 24 hours, the fan running at 80 revolutions per minute:—eight blades, by 80 revolutions, by 60 minutes by 24 hours = 921,600. This product represents the number of times in a single day that a weight of, at least, 500 lbs. is, as it were, instantaneously removed from the blades, and the shock resulting from the removal is transmitted to the fan shaft. The shaft is thus in a constant state of tremor, and sooner or later reaches its elastic limit. The consequent injury to the general structure of the fan is obvious.

The Walker Anti-vibration Shutter as attached to the fan at the Park Collieries removes this evil by effecting a perfectly gradual change in the pressure referred to, and so governs the discharge of the air as to cause it to pass, without objectionable eddying, in a continuous stream from the fan vanes into the chimney, instead of intermittently, and without the pulsatory action described.

The shutter is constructed in sections, any of which can be removed for the purpose of adapting the area of the opening to varying duties of the fan.

The fan is suspended eccentrically in a volute or spiral chamber.

In the experiments, the results of which are given in the annexed tables, elaborate precautions were taken to avoid error. Each airway was divided by wires into a number of similar and equal pallelograms, and the calculations are based upon the average of several measurements in each pallelogram. The anemometer used had been sent to the makers for adjustment for the purposes of these experiments. A competent person remained in charge of the engines to ensure a constant speed being maintained. The end of the water-gauge tube was fixed at right angles to the current, about half-way between the fan inlet and the pit, and was enclosed in a box filled with cotton waste to avoid false readings through fluctuation of water in the tube. The water-gauge readings were also checked at several points in the fan drift, and found constant.

In the experiments made to ascertain the coal and steam consumption, indicator diagrams were taken from the engines once in each hour, other observations being taken every half-hour. The results given are the average results yielded by an experiment extending over six hours.

The feed water passed through a Green's economiser before reaching the boilers.

The steam was generated by two Lancashire boilers, each 30 feet long by 8 feet diameter.

The fuel used was slack from the Wigan Nine-Feet and Wigan Four-Feet Mines.

In comparing the relative merits of the fan with the furnace as a ventilating appliance, the advantage is, without doubt, largely in favour of the fan. It is not uncommon for a furnace to consume 50 lbs. of coal or even more per horse-power per hour, in the air at the bottom of the upcast

pit; whilst the tables annexed show that by the employment of a fan the fuel consumption need not exceed 4·75 lbs. per horse-power per hour, in the air at the upcast pit bottom. In addition to this the fuel burnt at a ventilating furnace is usually of a superior quality, and therefore of greater value than that burnt under steam boilers.

The ventilating power of a furnace is limited, and when that method of ventilation is employed, in addition to the danger of introducing fire into a mine which may give off large quantities of inflammable gas, and the risk of setting fire to adjacent coal or other strata, trouble constantly arises from the corrosive action of the products of combustion upon shaft fittings and tubbing, also from collapse of brick-work and leakage of tubbing owing to contraction and expansion due to the wide range of temperature in the shaft. This leakage has in some cases been so great as to reverse the air current by the cooling of the shaft, and the momentum of the falling water.

The smoke and fumes are a sources of great inconvenience where the shaft is used for winding coal, and this is especially the case where the shaft has to be utilised for the descent and ascent of workmen."

TABLE A.—Record of Duty obtained from the "Indestructible" Ventilating Fan and Engines referred to in Mr. Higson's paper. Ventilator 24 ft. diameter by 8 ft. wide, with Twin Compound Condensing Engine, cylinders 22 in. and 38 in. diameter by 4 ft. stroke, and rope gearing.

No. of Test.	Revolutions of Ventilator per Minute.	Revolutions of Engine per Minute.	Volume of Air, Cubic Feet. per Minute.	Vol. per Revolution of Ventilator.	Cubic Capacity of Fan.	Volume per cent. Ventilator Capacity.	Water Gauges: At Ventilator, but away from Fan Inlets	Water Gauges: At Pit Top.	Water Gauges: In Mine.	Periphery Speed. Feet per Minute	H. P. in Air.	Steam Pressure.	Cut-off in H.P. Cylinder	Vacuum shown on Gauge.	I.H.P. in Engines.	Per cent. Useful Effect: Volume Air measured at Surface.	Barometer.	Thermometer in External Atmosphere	Thermometer in Fan Drift
							In.	In.	In.			Lbs.		In.			In.		
1	84·6	40	201,096	2377	3619	65·6	3	3	2·75	6378	95·47	90	1/8	28	154·7	61·7	30·64	44·5°	51·0°
2	98·5	46	232,073	2356	3619	65·1	4	4	...	7425	146·26	87	1/8	28·25	229·57	63·71	30·6	43·5°	50·5°
3	110	51·3	262,925	2390	3619	66	5	5	4·35	8292	207·15	90	1/8	28	322	64·3	30·6	43·0°	50·5°
4	118	56	286,895	2431	3619	67·1	6	6	...	8896	271·8	88	1/8	28	402·4	67·54	30·6	43·5°	51·0°

SUPPLEMENTARY DATA.

No.	From foregoing Statement. W. G. at Pit Top.	From foregoing Statement. Useful Effect.	Water Gauge at Fan Inlet.	Useful Effect.
	In.			
1	3	61·70	3·6	73·73
2	4	63·71	4·7	74·00
3	5	64·30	5·7	73·72
4	6	67·54	7·1	79·67

As some Mining Engineers are of opinion that the true Useful Effect should be based upon the Water Gauge taken in the Fan Inlet, and not away from the Fan, Mr. Higson—for the purpose of comparison—subsequently obtained the Water Gauge simultaneously at the Fan Inlet and at the Pit Top, and the above columns give readings therefrom with their respective Useful Effects.

TABLE B.—Showing Quantity of Coal Consumed and Water Evaporated by Two Lancashire Boilers, each 30 ft. long and 8 ft. diameter, supplying Steam to the Walker Patent "Indestructible" Fan and Engines, at the Park Collieries, Garswood, on January 1st, 1894.

Duration of Experiment.	Periphery Speed of Fan per Minute	Revolutions of Engines per Minute.	Revolutions of Fan per Minute.	Average Pressure per Square Inch in Engine Room.	Coal Used per Hour.	Water Evaporated per Hour	Water Evaporated per Lb of Coal Used.	Coal Used per Hour per Horse Power in Air in Drift.	Coal Used per Hour per Horse Power in Air in Mine.	Steam Consumed by Engine per I. H. P. per Hour.	Fuel Consumption per Hour, per I. H. P. in Engines.
6 hours.	Feet 8292	51·3	110	Lbs. 84·4	Lbs. 856·3	Lbs. 6872·5	Lbs. 8·02	Lbs. 4·13	Lbs. 4·75	Lbs. 20·7	Lbs. 2·6

CERTIFICATE OF EXAMINATION ISSUED BY THE KEW OBSERVATORY, RICHMOND, SURREY.

I hereby Certify that the AIR METER, No. 941, has been compared with the Standard Instruments of this Observatory, and found to record as follows:—

At 1000 feet per minute ... 99 per cent. of the true amount.
„ 1500 „ „ ... 99 „ „ „

At 2000 feet per minute ... 99 per cent. of the true amount.
„ 2500 „ „ ... 99 „ „ „

(Signed) CHARLES CHREE,
Superintendent.

KEW OBSERVATORY, *January*, 1894.

NOTE.—Immediately after the experiments, of which the results are given in the tables, were completed, the Anemometer used was sent to be tested at Kew Observatory, the result being as shewn on the Certificate.

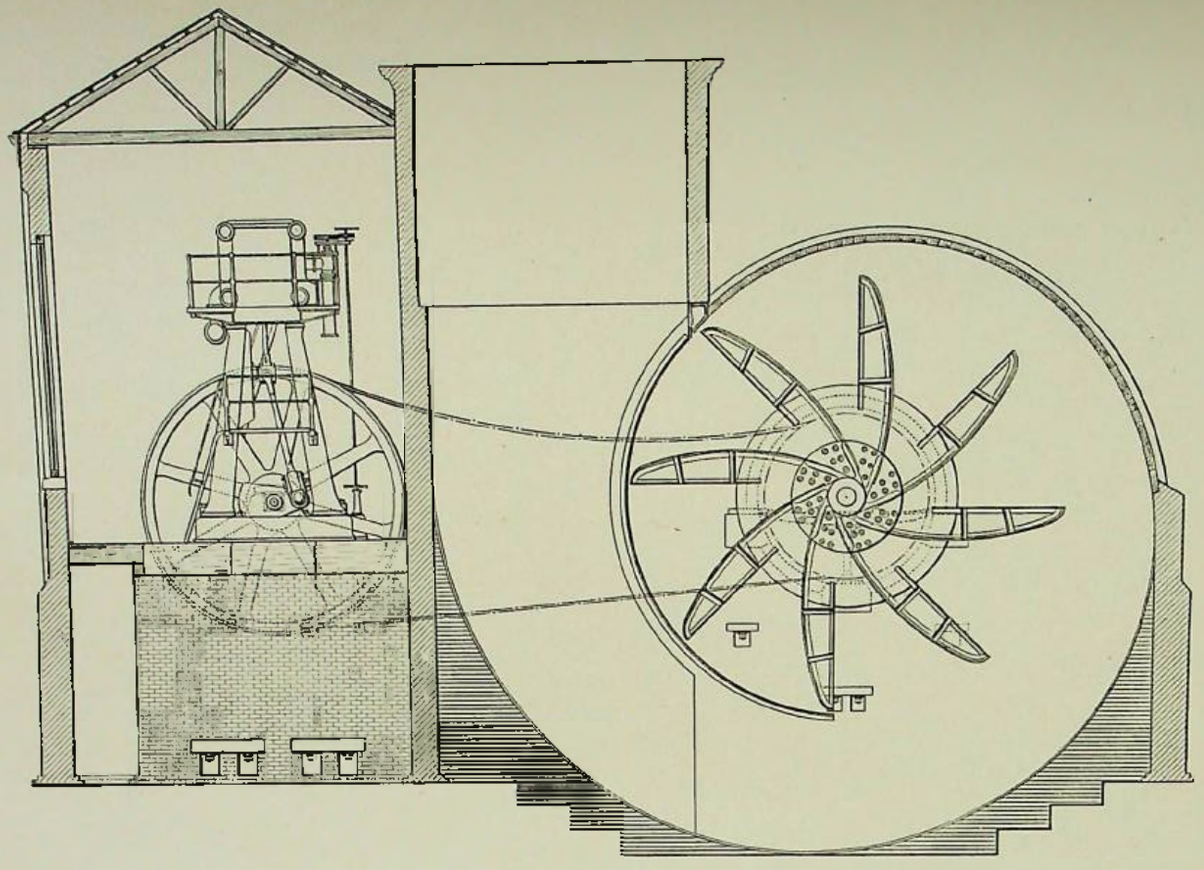
VENTILATING FAN WITH VERTICAL ENGINES.

The outline plan shows a Fan worked by Vertical Engines of the Compound Corliss principle. The installation, from which the sketch is taken, was supplied for a heavy duty, about 500,000 cubic feet of air per minute, and 6 inches Water Gauge.

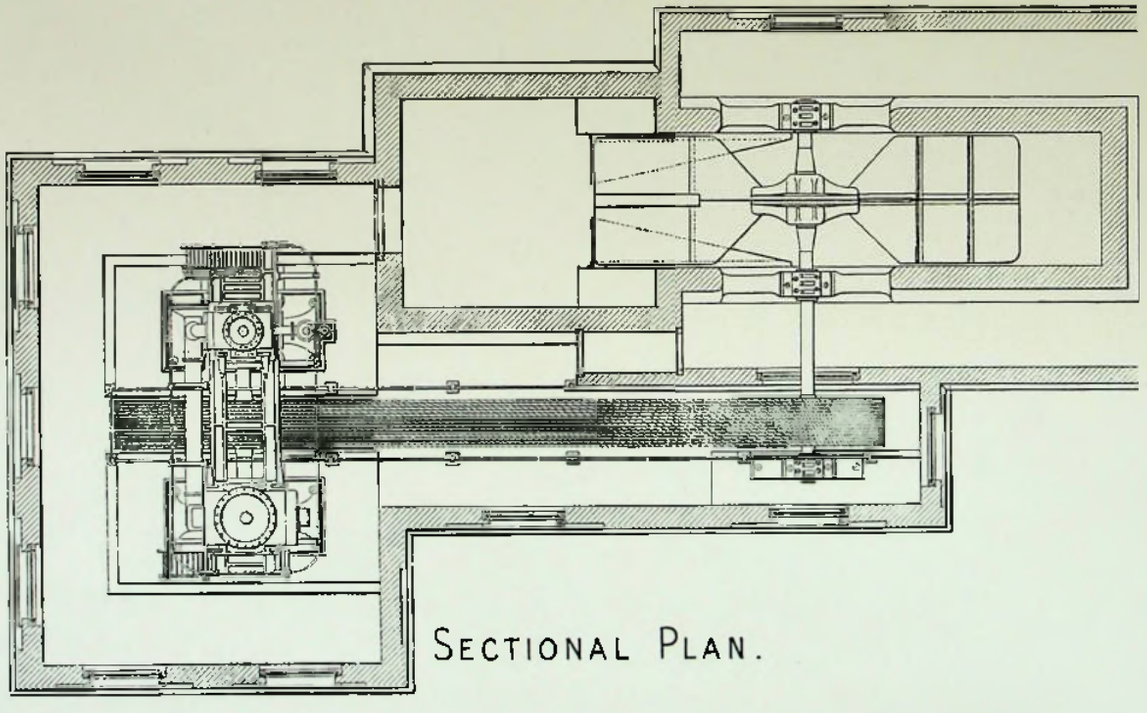
The sketch is sufficiently clear as to require little explanation.

The great majority of our Fans are driven by Horizontal Engines. As the sketch shows, Vertical Engines can be supplied, constructed either on the simple high pressure principle, or the compound,—or compound-condensing principle, as may be desired. The Engines may also have Slide-valves, or Corliss valves, as preferred.

Walker Brothers Indestructible Ventilating Fan.
Rope-Driven with Vertical Corliss Engines.



Sectional Elevation.



Sectional Plan.

DIRECTLY-DRIVEN FANS.

(See Outline Sketch.)

We have had many years' experience in the application of Fans for the Ventilation of Collieries worked directly by the Steam Engines, having constructed, among these, some of the most powerful in the country. Fans 46 feet diameter, besides a large number of smaller dimensions.

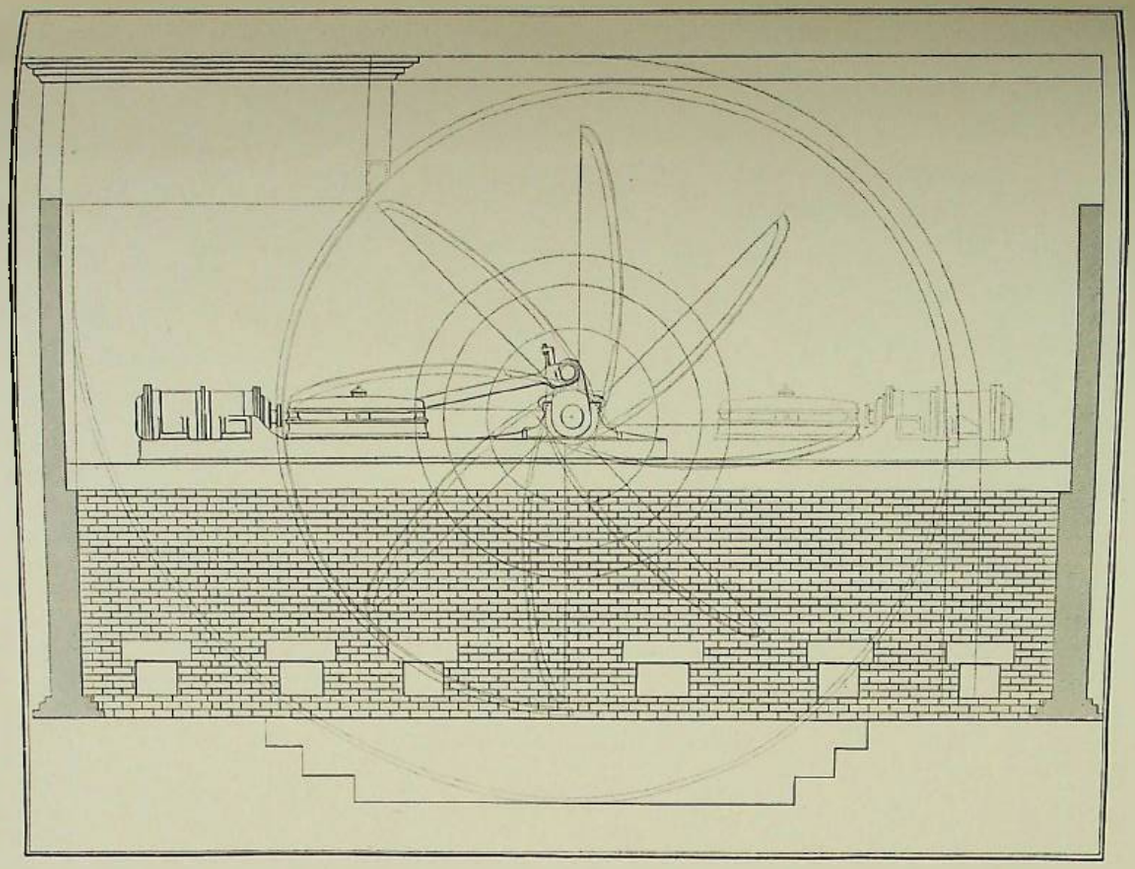
The outline sketch shows the "Indestructible" type of Fan when worked directly by the Engine. We supply the Engines either on the Simple High Pressure, the Compound, or the Compound Condensing principle. The sketch shows the High Pressure type, with a Stand-by Engine when required. The Stand-by Engine is shown in dotted lines. The majority of our Directly-driven Fans are worked by Horizontal Engines. Some, however, are worked by Vertical Engines. For moderate volumes of air and low water gauges the directly-driven principle is satisfactory, but we recommend Rope-driven Fans for the heavier duties.

Our position with reference to the question of Directly-driven or Rope-driven Fans, is one of discrimination and selection for the duty to be performed. It is essentially one of experience and of judgment in each particular case.

We recommend moderate velocities for the Directly-driven Fan, as our observation of the working of Fans of all kinds in every mining district of Great Britain has proved the danger of running machinery at excessive velocities for the important duty of ventilating a colliery. It will be observed from the illustration that the brickwork, as required for our Directly-driven Fan, is trifling in quantity and bulk, and of the simplest character in construction. The walls of the Fan casing are perpendicular, with the circular covering of timber.

The arrangement of admitting the air from the Pit Shaft on both sides enables the Fan to work in equilibrio—thus avoiding the loss of power by side friction. With the acknowledged advantages afforded by the encased, or close running principle of Fan construction, there is the further advantage afforded by the chimney of discharging the noxious air from the mine, at a moderate height above the floor line of the surface of the Colliery.

SECTIONAL ELEVATION.



"WALKER" PATENT "INDESTRUCTIBLE" VENTILATING FAN,
DIRECT-DRIVEN, WITH STAND-BY ENGINE.

PLAN.