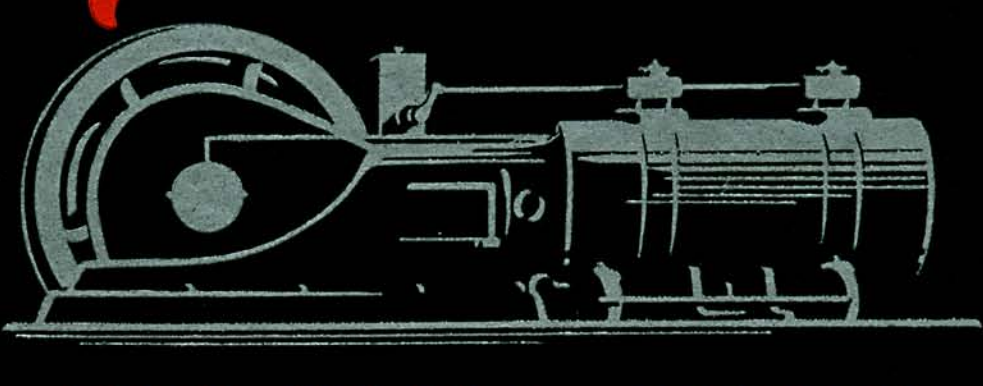
The UNA-FLOW Engine



AMES IRON WORKS, OSWEGO, N. Y.

DIVISION OF PIERCE BUTLER RADIATOR CORPORATION

The Ames
UNA-FLOW
Engine

THE MOST ECONOMICAL
AND EFFICIENT FORM OF
PRIME MOVER DEVELOPED

BULLETIN 1937

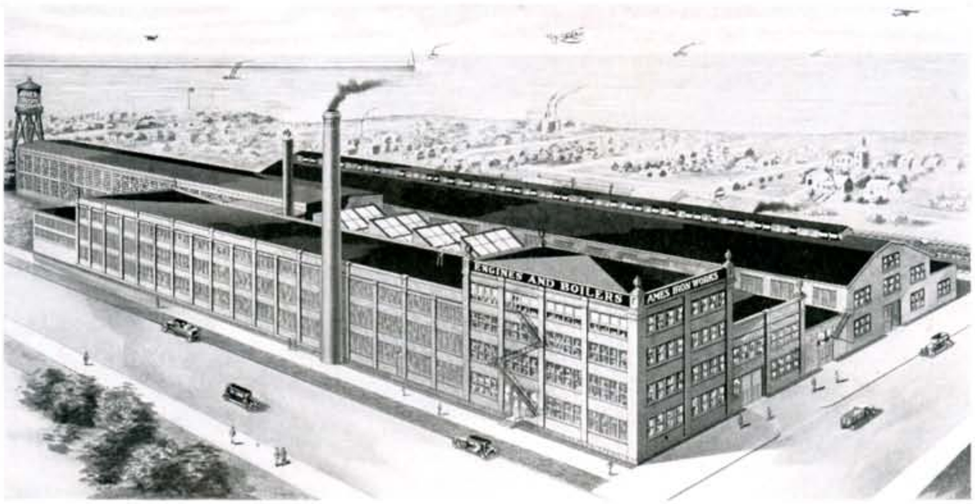
Manufactured by

AMES IRON WORKS

Division of Pierce, Butler Radiator Corp.

OSWEGO, NEW YORK

OFFICES IN ALL PRINCIPAL CITIES



Works, Oswego, N. Y.

FOREWORD

Ames Iron Works was established in 1854 in Oswego, New York, and continuously since that year have been builders of highest grade Steam Engines, the unvarying excellence of designs and materials of which have earned and maintained for us an unsurpassed reputation as builders of good engines.

Ames Iron Works have built in turn superior engines of Slide Valve, Corliss Valve, Compound and Una-flow types as each in succession demonstrated its advancement over the type preceding it. Based upon approximately seventy years experience as engine builders of nearly all successful types, we feel qualified to speak authoritatively on the comparative merits of each, ending with the most reliable and economical "AMES UNA-FLOW".

INTRODUCTION

FROM the time Reciprocating Steam Engines were first used for commercial purposes they have been known to be very wasteful of steam, principally on account of low cylinder efficiency.

Until recent years this established fact was not a matter of great concern to those using engines, as most installations were moderate in size, coal was comparatively cheap, and freight rates and wages for handling fuel were reasonably low.

In recent years, however, the cost of power has greatly increased, whether it be purchased or developed in individual plants, and from many who have been obliged to purchase fuel to generate steam for power, there has come an imperative and continuous demand for an engine of higher efficiency to afford relief and to compensate for the frequent advances in costs of power fuels and other increased expenses.

This demand was founded upon economic necessity, as competitive manufacturing methods and prices, production requirements and adequate profits were vital factors in nearly every business and to balance and successfully meet these important conditions, in addition to the higher costs of all materials and increased operating and selling expenses, it was found necessary to secure higher efficiency in all branches of a business.

This demand has been well satisfied in so far as it refers to efficient power equipment and reduced costs of producing power. The engineering profession and manufacturers of all classes of power equipment have accomplished great improvements in all directions and by their talent, time and expenditures have now made it possible to install a Power Plant that will produce a specified horsepower for less than one-half the amount of fuel required in the past.

The engineering profession and manufacturers of power equipment have by their experiments, expenditures and practical accomplishments rendered a great service to industry and commerce and have contributed a proper share toward the prosperity of our country.

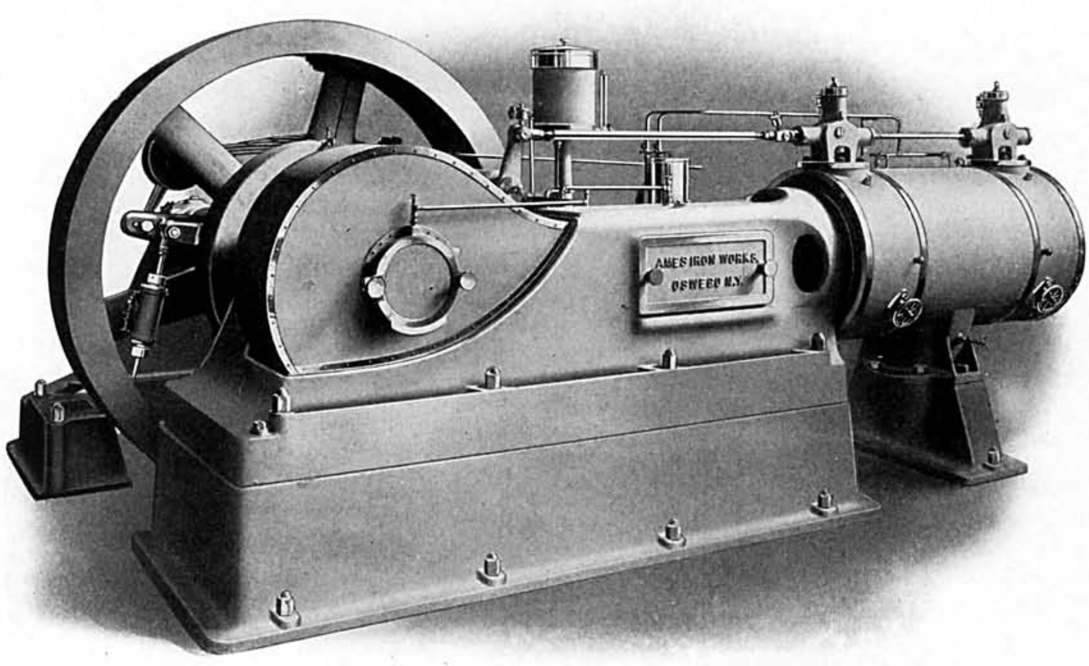
The Power Plant is no longer considered an expense. It is an investment and like other investments it will only bring the expected returns if properly selected and purchased.

As the Power Plant cannot be exchanged nor its principal component parts replaced without considerable interruption of service and large expense, its selection should be carefully and competently made. Equipment should be proposed and selected from an engineering viewpoint, while theoretical advantages and sales expediencies should have but little consideration, as the Power Plant is an adjunct of a business too vital to be subjected to chance or experiment.

THE UNA-FLOW ENGINE

LIKE most other improvements accomplished by the Mechanical and Steam Engineering profession, the perfected Una-flow Engine is a product of extensive experiment, research and development. It is now far beyond the development stage and is perfected tc a degree equal to any other form of prime mover.

This type of Engine was experimented with by Eaton in the United States in 1857 and built by Todd in England in 1885, but was not made a commercial success until 1908, when Professor Johannes Stumpf of Charlottenburg combined with great success the three necessary basic features required to secure the maximum thermodynamic superiority inherent to the Una-flow principle. These features are: (1) exhaust ports in center of and around cylinder at end of stroke, which in the true Una-flow design are the means of discharging sufficient exhaust and eliminate the counterflow of cooled expanded wet steam? (2) elongated piston, functioning as exhaust valves? (3) steam jacketed cylinder heads, maintaining hot cylinder ends, and imparting heat to compression steam. All three of these features, however, are combined and used in conjunction with steam-tight poppet valves for admission of steam to the cylinder.



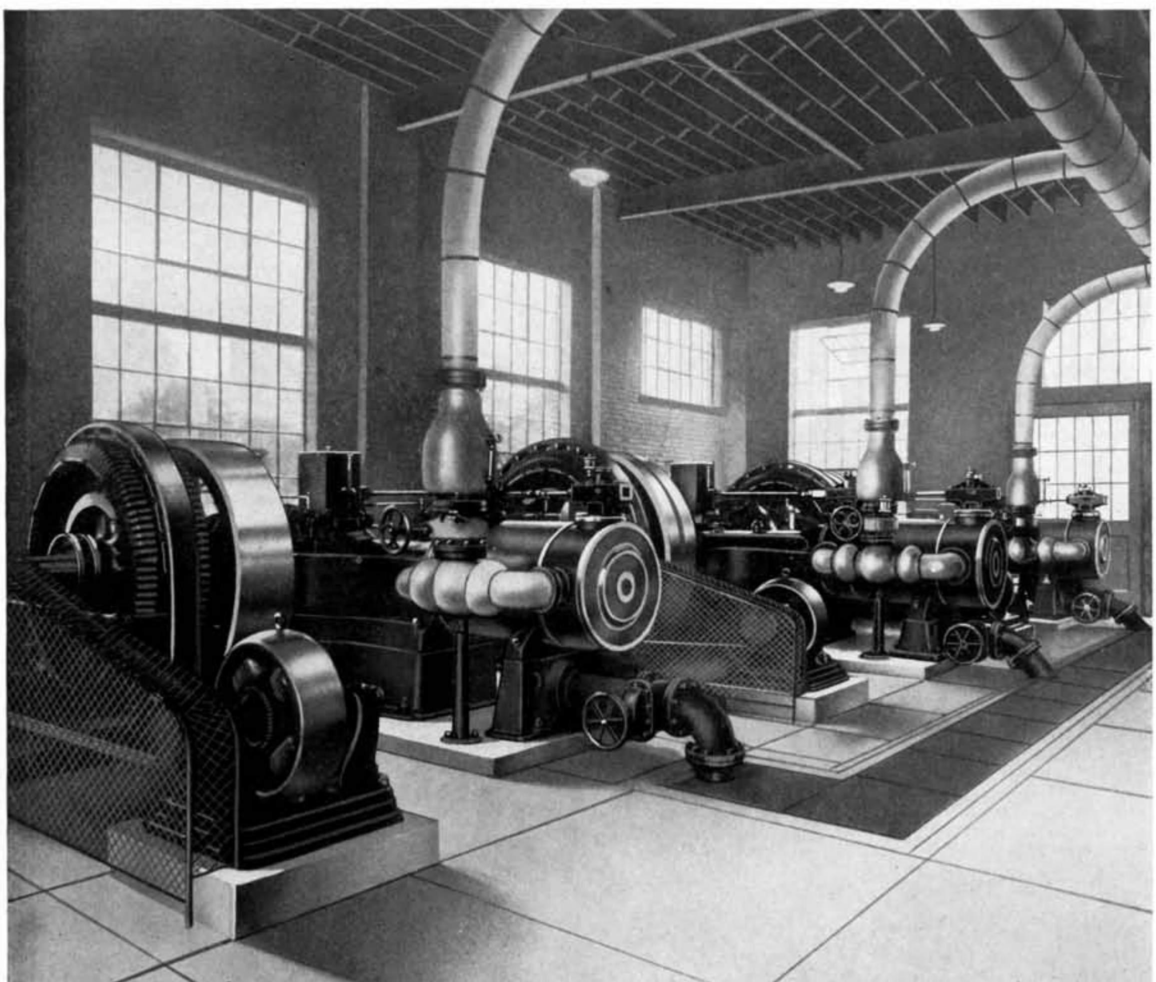
The First Stumpf Una-Flow Engine Built in America
Size 15 x 16. D. C. to 100 K. W. Generator. This engine was built in 1913, and has been in operation since that time

Closely following the economic and commercial success of Prof. Stumpf's Una-flow Engine, the Ames Iron Works investigated his development and acquired the rights to manufacture this engine in the United States and were the first engine builders in America to produce and install a true Una-flow Engine under Stumpf patents. This was in 1913 and since then a number of other American engine builders have concurred in our judgment as to the merits of the Una-flow design.

The true Una-flow cycle of operation produces the following important thermal advantages as compared with the Counter-flow cycle of various types.

1. *Reduced Steam Consumption*, due to great reduction in initial condensation and re-evaporation.

2. *More Complete Expansion of Steam*, due to earlier cut-off of steam during stroke.



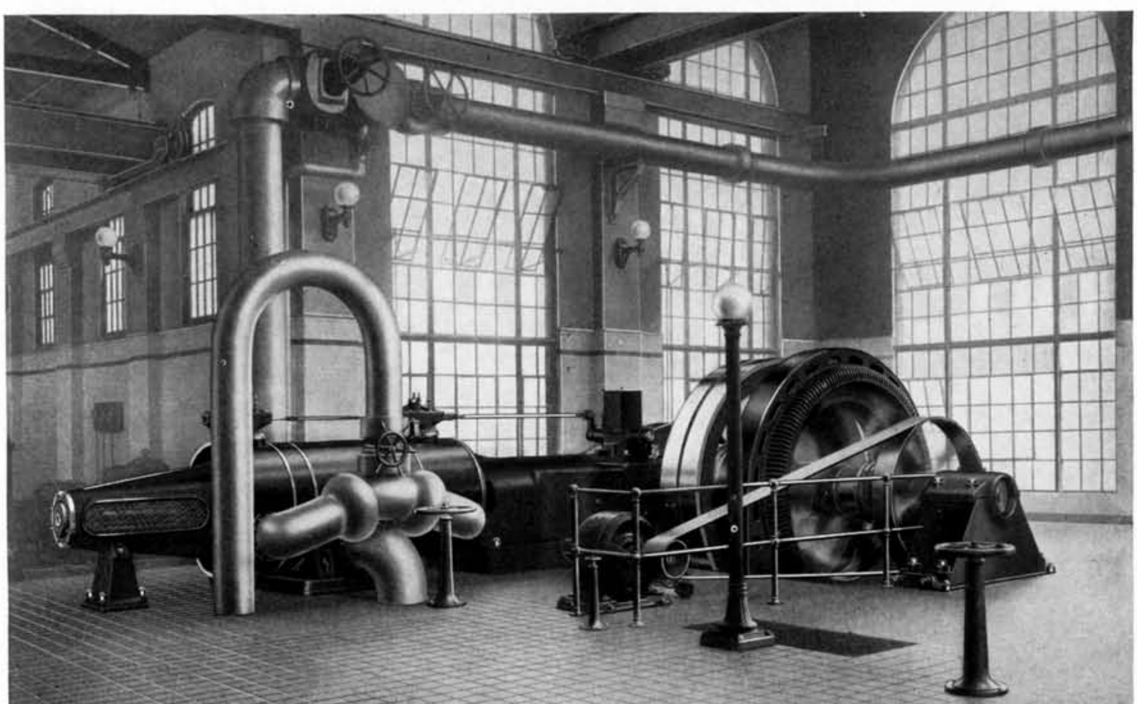
Installation of Ames Una-Flow Engines in Municipal Lighting Plant

3. *Practically Same Steam Consumption per Horsepower Hour at All Load Points,* due to all admission steam being available for effective work. At light and moderate load points highly important steam savings are made, as the large ratio of admission steam wasted by heat exchanges in Counter-flow Engines is avoided.

4. *Simplicity of Design and Reduced Number of Working Parts.* These features provide reduced maintenance and renewal expenses.

5. *Use of Unconfined Poppet Valves,* which admits of securing modern low steam economies by application of high pressure steam and superheat temperatures without the probability of distortion and cutting of valves due to applied heat, as is common in the several types of confined valves, usually installed in the Counter-flow Cylinder Engines. As no lubricant is necessary on faces and seats of poppet valves, the usual costly repairs and renewals occasioned by the higher steam temperatures burning off the oil from confined valves and seats is entirely eliminated and the waste of steam thru damaged and leaking valves is prevented.

6. *Una-Flow Engines* may be safely operated at higher rotative speeds than Corliss Valve Engines, due to simplicity and characteristics of valve actuating gears and valves.



Industrial Installation
1250 H. P. Ames Una-Flow Engine D. C. to Alternating Current Generator

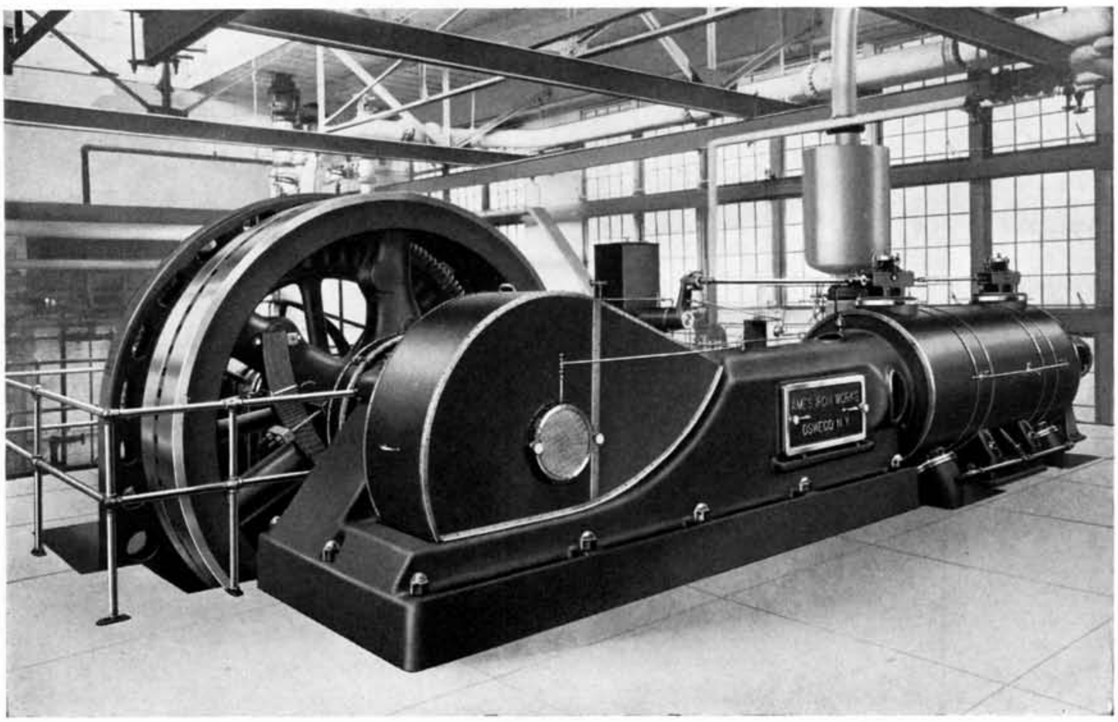
The Una-flow principle greatly reduces two of the large losses existing in steam engines of the Counter-flow cylinder type, whether they be of the Corliss Valve, Slide Valve or Piston Valve designs.

The first and most important loss is known as internal cylinder condensation, which occurs when the hot steam from boilers entering the cylinder comes into contact with cylinder walls and heads, which have been cooled considerably below the temperature of incoming steam during the expansion and compression strokes.

This cooling of the cylinder walls, re-evaporation and heat extraction occurs during the exhaust stroke, and the heat absorbed is discharged into the exhaust without doing effective work. The large amount of heat so taken from the cylinder walls and steam ports must be restored by the hot incoming steam, which, if not superheated, can do this re-heating only at the expense of condensation, which being a complete loss must be compensated for only by increased steam and fuel consumption.

The second referred to loss of importance in all types of Counter-flow Engines is incomplete expansion resulting from wastage of part of admission steam not converted into useful work. The lighter the load carried the greater the ratio of incoming steam given up as loss for re-heating of cooled cylinder areas.

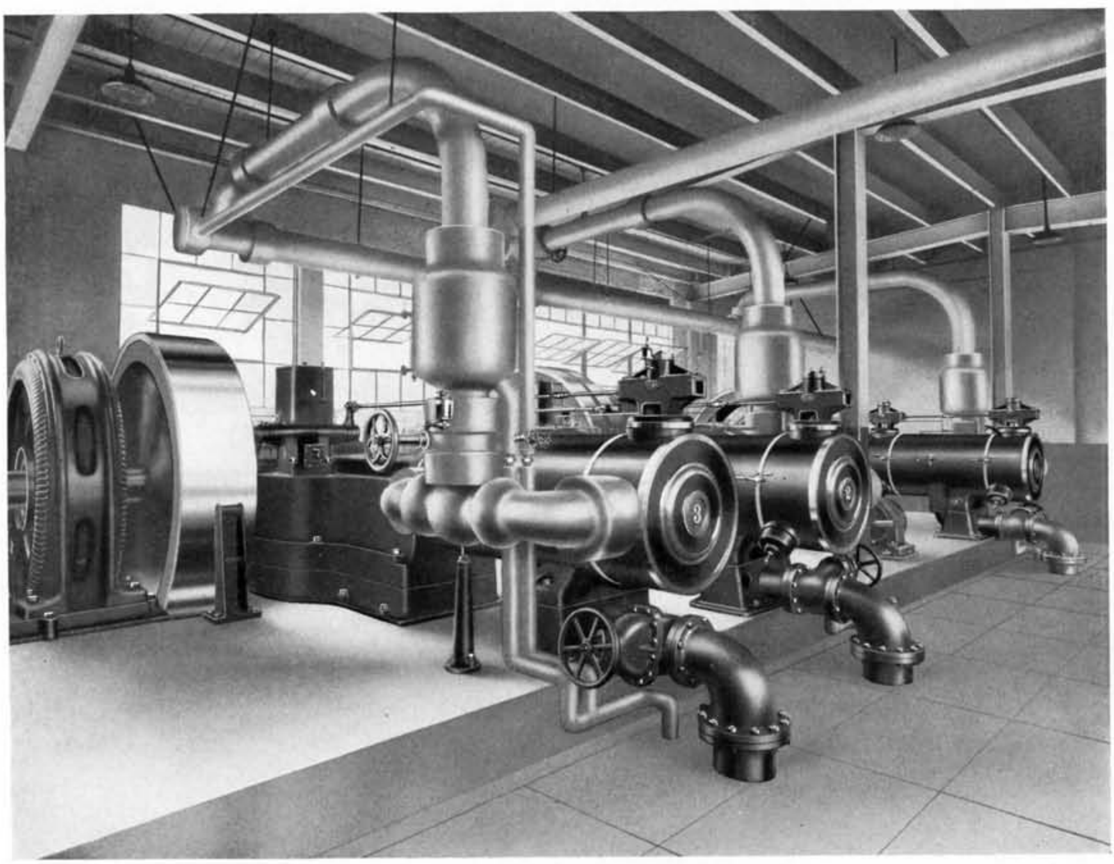
This loss due to incomplete expansion in the Una-flow cylinder can be reduced by cutting off the steam supplied to cylinder earlier in the stroke as the earlier the cutoff the smaller the loss from incomplete expansion.



Industrial Installation
1000 H. P. Ames Una-Flow Engine D. C. to Alternating Current Generator

In Counter-flow Engines of all types, this shortening of steam cutoff can only be done at the expense of added internal condensation and it is generally agreed that this condensation loss balances the gain of shortening of cutoff at about twenty-five per cent of stroke and there is little gained in economy by reducing the cutoff beyond that point. The reduction of cylinder temperatures due to light loads and corresponding earlier cutoffs is the principal cause of the Counter-flow types of engines being so wasteful of steam at light and moderate load points (valve leakage not being lost sight of).

The Una-flow Cylinder overcomes almost entirely the loss due to incomplete expansion, as the cylinder heads and ends are not swept by cooled expanded steam, nor exposed to atmospheric or lower temperatures and as these cylinder areas remain as hot as the temperature of incoming steam and are not required to give up heat for re-evaporation, the incoming steam does no re-heating and is all available for and converted into effective work. It is, therefore, obvious that less steam is required to be admitted to cylinder to do an equivalent amount of work and the admission steam is cut off at a correspondingly earlier point of stroke. For non-condensing service this is generally about twenty per cent for current average steam pressures and temperatures, which reduction verifies the merits and savings of the Una-flow cylinder.

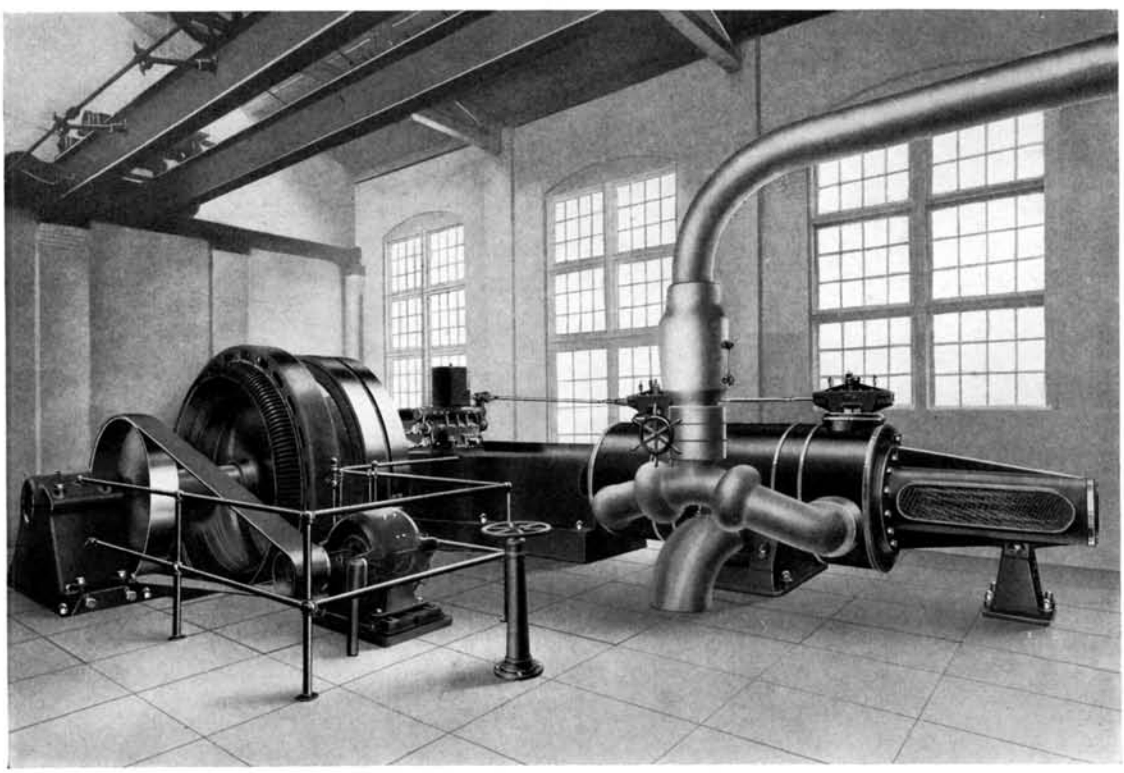


Installation of Three (3) 350 H. P. Ames Una-Flows in Municipal Lighting Plant

This superiority is obtained by applied unalterable laws of thermodynamics and cannot be secured by sacrificing these necessary laws to expediency of omitting essential basic features and substituting modified construction to admit of cheaper manufacturing costs and to provide useful theories, illustrations and sales attractions.

To meet the imperative demand for an engine of greatest possible steam economy, which would necessitate exhausting into a vacuum, the first Una-Flow Engines were designed for condensing service. It soon developed, however, that this type engine was proportionally economical for non-condensing service. For this service increased volumetric clearances in ends of cylinders is provided to accommodate this residual steam after being compressed for ninety per cent of stroke against progressively hotter cylinder zones.

The true Una-flow cylinder with ends constantly hot, as previously described, does not admit of loss by condensation, but maintains its thermal superiority, and as compressed steam during its relatively long compression and interval of heat absorption (from cylinder ends and head jackets) attains temperatures equal to that of incoming steam and has value equal to that of admission steam; thereby reducing amount of steam required for following stroke.



Industrial Installation
1250 H. P. Ames Una-Flow Engine D. C. to Alternating Current Generator

COMPRESSION PRESSURE REQUIREMENTS

Statements are sometimes made that considerable additional power must be applied to face of piston under pressure to overcome the pressure of compression on opposite face and that unnecessary waste results. Such statements are misleading as the great merit of the Una-flow cylinder is steam economy at all points of load, which is made possible only by *early* (*not high*) compression against areas constantly hot. A small amount of effective power is required to overcome compression pressure and this negligible amount is best evidenced and truthfully shown by no-load friction indicator diagrams which combine compression pressure and friction load requirements, and is further verified by a comparison of brake horsepower steam consumption economies of the true Una-flow cylinder with other engines.

ADVANTAGE OF EARLY COMPRESSION

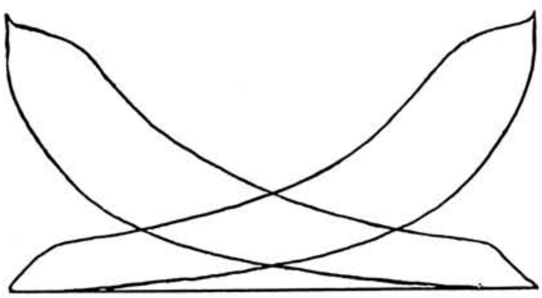
The true (two valve) Una-flow Engine is sometimes specified as producing excessively high compression when operating non-condensing. Such statements are erroneous if proper cylinder clearances are provided, as the amount of clearance volume is fixed and cannot vary, therefore the pressure of final compression cannot be changed. The volumetric clearances are designed to produce final compression pressure to a point very nearly equal to admission steam pressure, which is an ideal and efficient operating condition.

From the above it will be obvious the true Una-flow should be stated as having *early* compression and *not high* compression. Early compression with its previously described thermal advantages is very desirable as it produces large savings of steam and also provides a gradual cushioning of inertia of reciprocating weights and relieves pins, boxes and other parts of considerable duty required for alternate change of direction of weight made twice for each shaft revolution.

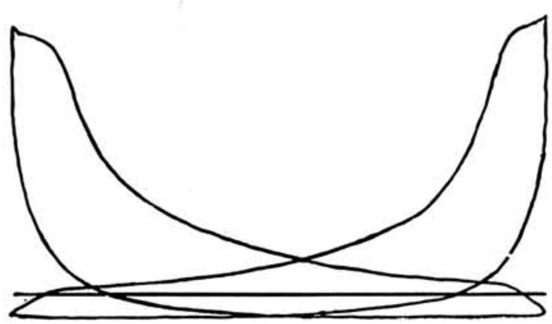
Engines having secondary or auxiliary exhaust ports controlled by piston travels and having small fixed volumetric clearances produce under parallel operating conditions the same final compression pressure as the true Una-flow type, as the multiple exhaust type merely *delays* but does not reduce final compression pressure, while this delayed compression *sacrifices* the high economy at *light load points*.

The Una-flow Engine at normal rating will operate on less steam per horsepower hour than any Counter-flow type and due to the almost complete elimination of internal cylinder condensation it will at fractional loads develop a horsepower on from 20 to 50% less steam than that required by the Counter-flow Engine.

See comparative economy curves on page 14.



Typical Indicator Diagram From Non-Condensing Engine



Typical Indicator Diagram From Condensing Engine

COMPARISON OF STEAM FLOW AND TEMPERATURE CONDITIONS EXISTING IN CYLINDERS OF VARIOUS TYPES OF ENGINES

On page No. 13 is shown cross-section drawings of cylinders of usual types, which are presented as graphic illustrations and not for accuracy of respective designs and details.

For the purpose of comparison we have shown the following colors to represent:

Orange: Admission steam.

Black: Arrows: Exhaust steam. Solid: Metal parts.

Red: Cylinder areas constantly hot (Una-flow only).

Blue: Low pressure steam (Compound Engine only).

Two (2) 500 H. P. Ames Una-Flows installed in Plant of Compania Industrial Jabonera, Gomez Palacio Durango, Mexico. This entire design and installation including Engines, Generators, Switchboard, Condensers, and Superheaters, made by Ames Iron Works

By following the directional flow of steam in compared cylinders, obviously the marked thermal superiority of the Una-flow cylinder will be apparent.

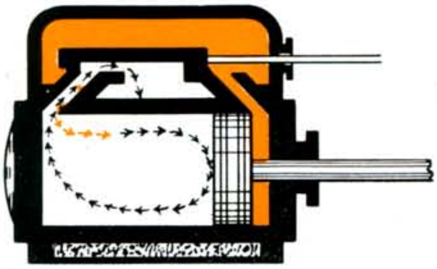
Figure No. 1, illustrates the principle of the Simple Slide or Piston Valve cylinder. This is the oldest and least efficient of any type now in use. The alternate heating and cooling of common admission and exhaust ports results in a large portion of live steam being subjected to continuous heat exchanges resulting in condensation, which is not of value for effective work and is therefore a complete net loss.

Figure No. 2, illustrates the well known Single Cylinder Corliss Four Valve Type. The separation of admission and exhaust ports considerably reduced the extreme alternating temperatures of valves and ports (as in Figure No. 1), thereby lowering the portion of live steam given up as loss to heat exchanges, which combined with the use of Corliss valves provided an acceptable improvement over previous types and the Corliss Engine has in past years been a very satisfactory one. It is, however, not capable of producing the steam economies now demanded and obtainable, and due to the characteristics and length of confined Corliss valves, high temperature and superheated steam cannot be used without danger of troublesome and expensive results.

Figure No. 3, illustrates the Compound Cylinder Corliss type, which proved to be a more economical engine than the single cylinder type, as the use of high and low pressure cylinders divided into two ranges the difference between initial and exhaust temperatures. This construction overcomes to a large extent the heat exchanges applying to cylinder areas, valves and ports as in former types and under the improved thermal conditions more complete expansion of steam is obtained. This type was more economical in steam consumption than engines preceding it, but also had its points of disadvantage. The Compound Engine was naturally more expensive to build and install, and occupied more floor space in engine room. There were also unavoidable losses due to radiation and the transfer of steam from one cylinder to the other, so the overall advantage and economy derived from the Compound Engine did not fully meet the increasing demand for an engine of highest efficiency, which would perform satisfactorily under the modern steam temperatures and higher rotative speeds essential for producing further savings in steam consumption.

Figure No. 4, illustrates the true Una-flow type, by which is meant a cylinder without exhaust valves and ports at ends or intermediate points, which expose cylinder areas to atmospheric or lower temperatures, thus partly defeating the thermal superiority of the Una-flow principle. The true Una-flow cylinder as shown has two ends constantly hot and a central exhaust belt with constantly low temperature. Steam flows from valves in cylinder ends and is exhausted direct thru ports in center at end of stroke, or in a uniform flow, from which course the word Una-flow is derived. By thus avoiding alternate heating and cooling of cylinder areas, internal condensation and re-evaporation is prevented, which in turn admits of earlier steam cutoff and almost complete expansion of steam results. The use of Poppet valves allows steam of highest temperatures to be safely applied with no danger of interrupted service and replacement expense due to distortion and lubricating troubles.

1

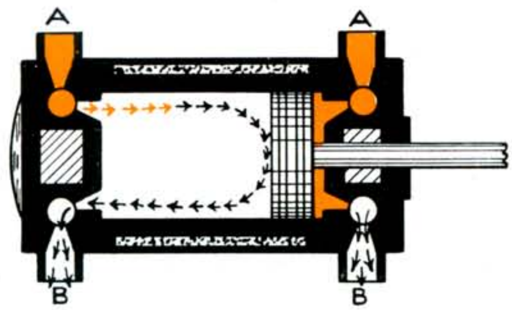


Simple Slide or Piston Valve Type

Hot admission steam enters cylinder and cooled expanded steam is exhausted thru same ports. This alternate heat exchanging results in excessive initial condensation losses.

Result = Large waste of steam.
Expansion incomplete.

2

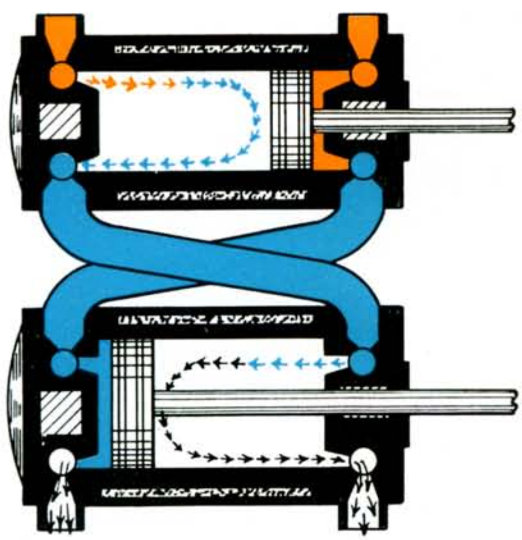


Single Cylinder Corliss 4 Valve Type

Hot admission steam enters cylinder by upper ports "A". Cooled expanded steam is discharged thru exhaust ports "B". The separation of ports reduces initial condensation under Fig. 1.

Result = Reduced steam waste.
Expansion incomplete.

3

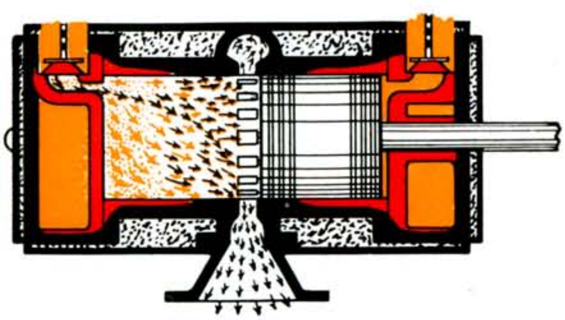


Compound Cylinder Corliss Type

Use of high and low pressure cylinders divides into two ranges the difference between admission and terminal temperatures. This construction reduces further the losses of initial condensation as occur in Figures 1 and 2.

Result = Further saving of steam at heavy loads only.
More complete expansion.

4



Una-Flow (2 Valve Type)

Hot admission steam enters cylinder at ends and cooled expanded steam is exhausted thru ports in center of cylinder—thereby avoiding constant heat exchanging and almost eliminating initial condensation.

Result = Large saving in steam consumption at all loads.
Practically complete expansion.

Steam Consumption Curves ~ Showing Relative Economies of:

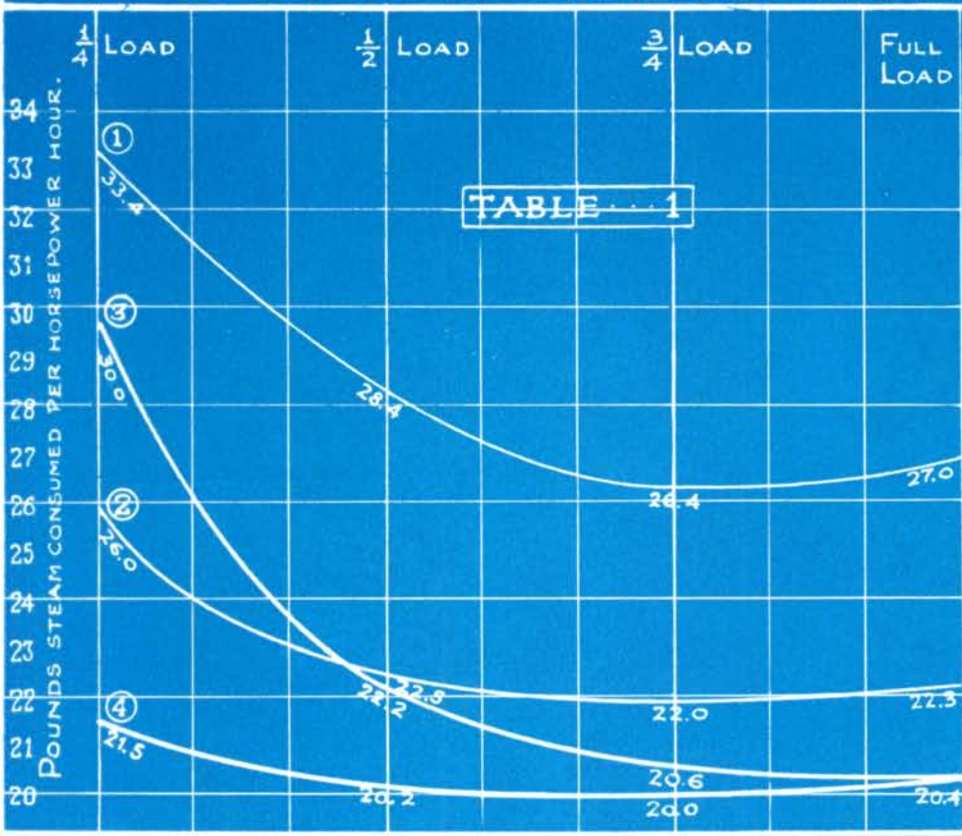
1 = Single Cylinder Slide or Piston Valve Engine
2 = Single Cylinder Corliss 4 Valve Engine
3 = Compound Cylinder Corliss Engine
4 = Una-Flow Engine – 2 Valve Type.

} Of about 200-horsepower capacity.

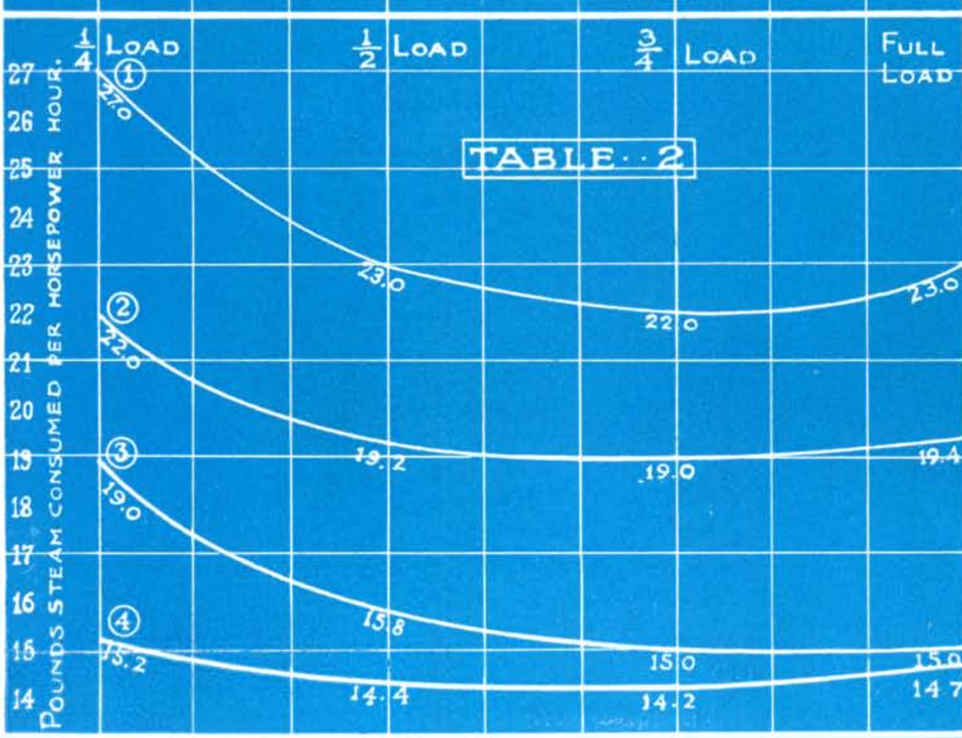
Table No. 1 Engines operating under 150 lbs. saturated steam exhausting against atmosphere

Table No. 2 Engines operating under 150 lbs. saturated steam exhausting into vacuum of 26 inches

Note = All steam consumption amounts are averages of various proposal guarantees and operating results of several makes of engines and are considered fair for comparison.



Average steam consumption of four points of load. %	Excess of steam consumed in percent over Una-flow based upon averaged loads %	Net tons coal and expense saved per year estimated by assuming: Coal at \$6.00 net ton delivered; Load – average – 50% 100 HP.; Service – 10 hrs per day 1000 HP hrs for 300 days per year; Boiler evaporation – 8# to 1# — Tons	Dollars	Saving will balance 12% combined interest and depreciation on amounts shown — Dollars
28.8	40.0	154	922	7517
23.2	13.1	43.1	259	2158
23.3	13.6	37.5	22 5	1875
20.5				



Average steam consumption %	Excess %	Tons	Dollars	Dollars
23.7	62.3	161	967	8058
19.9	36.3	90	540	4500
16.2	11.0	26.2	157	1308
14.6				

Ames Iron Works.

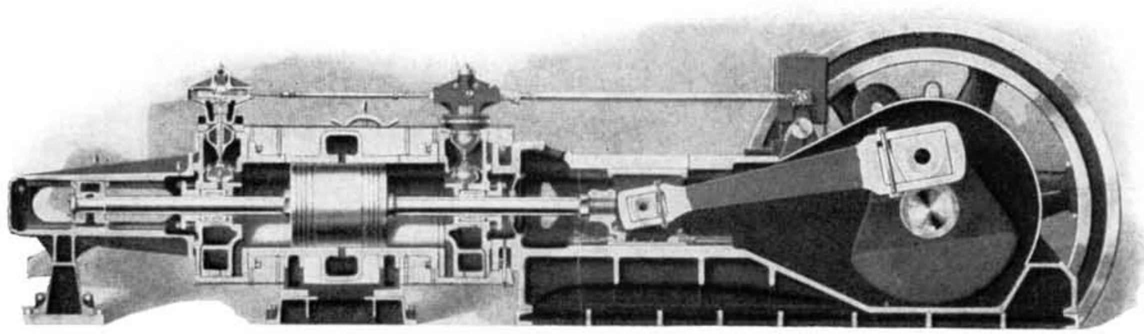
SIMPLICITY OF DESIGN

IN the design and development of the "Ames Una-flow" Engine no small amount of consideration has been given to the one outstanding feature, which appeals to every chief engineer, or those having the engine in charge, "Simplicity of Design".

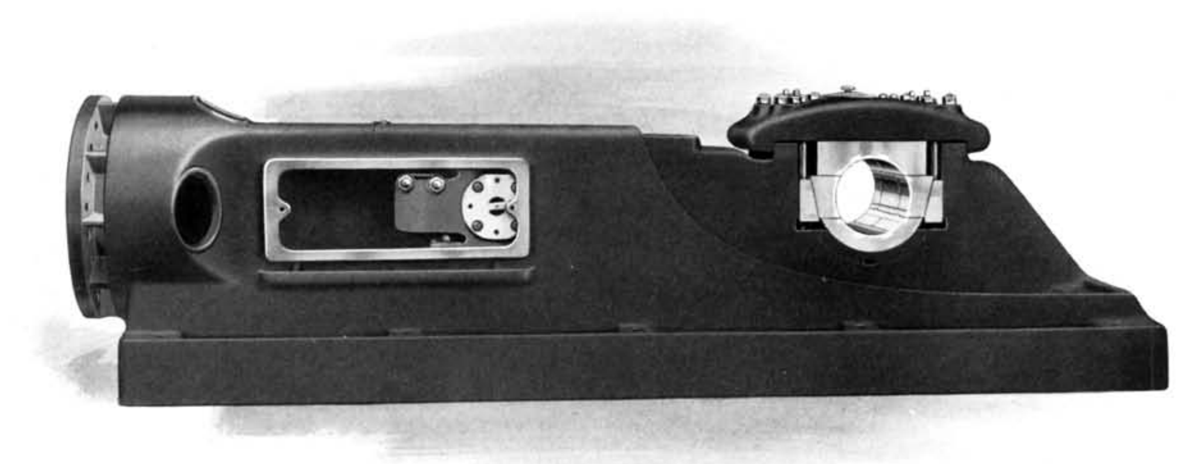
Throughout the various stages of steam engine design from the single cylinder throttling engine to the triple and quadruple expansion types, tandem or cross-compound engines, there has at almost every advanced stage been added of necessity more complicated actuating valve gears, which in turn require more attention, and more frequent repairs or renewals.

The "Ames Una-flow" is designed with a valve actuating gear, which is considered by users of this engine as the simplest and best that it is possible to design; there are but three working joints in the entire valve gear between the governor and valves. This we consider a minimum when it is remembered that some builders have as many as ten joints in the admission valve gear to secure no better results.

This same degree of simplicity is followed throughout the entire design of the engine without sacrificing in any way "more satisfactory results", sometimes claimed for more complicated valve actuating gears or other operating parts. This will be readily seen by referring to the detail cuts of the engine parts on the following pages with description of same.



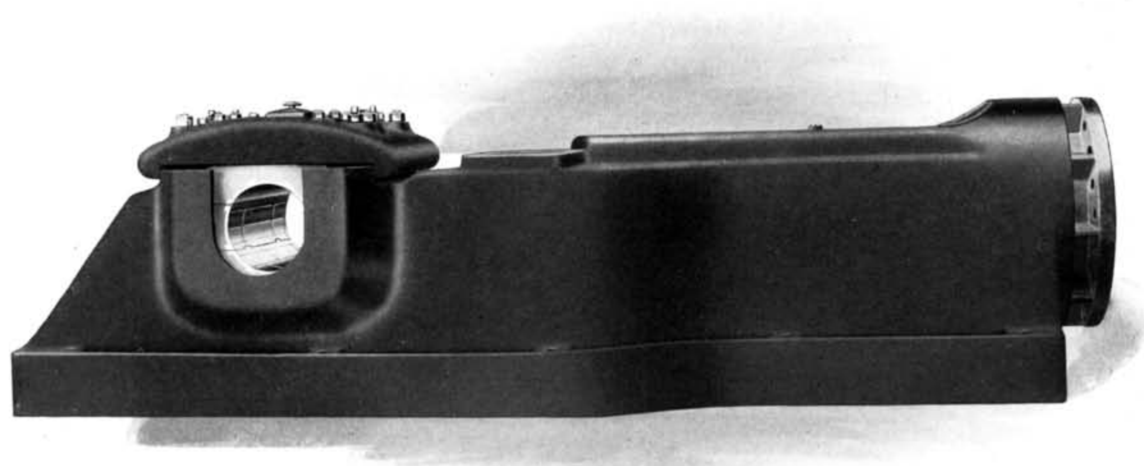
Longitudinal Section Thru Frame, Cylinder and Tail Rod Guide



Crosshead Opening Side of Frame

THE FRAME

The frame of the Ames Una-flow is of box section, heavy duty, side crank type, cast in one piece. The ribbing and reinforcing is done on the inside of the casting. The head of the frame is centered, bored and turned at the same time the guides are bored, thus insuring perfect alignment. The seats for the main bearing shell are machined concentric with the shaft on all sizes of frames, thus permitting the removal of the main bearing from the frame casting without raising the shaft more than one one-hundredth of an inch. This is a most important feature and one that is incorporated on all sizes and types of Ames Engines.

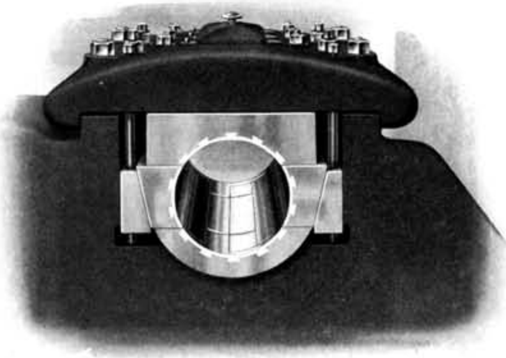


Governor Wheel Side of Frame

MAIN BEARING

Main Bearing Lock Bolt Adjustment

The main bearing consists of a three-piece box as shown at the right on smaller sizes and a four-piece box as shown below on the larger sizes, with a heavy genuine babbitt lining peened in place and bored to gauge. The bearing is carried rigidly in the frame casting and securely held by means of heavy bolts, which pass through the cap and frame housing. This rigid fastening of the bearing in position does not inconvenience the adjustment, as same may be adjusted to the finest degree while engine is in operation. On the smaller sizes this adjustment is made by means of lock bolts thru the frame housing against the quarter box. On twenty-seven inch stroke engines and larger the adjustment is made by means of wedge.

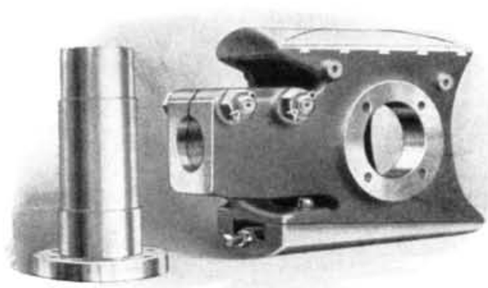


Main Bearing Wedge Adjustment

CROSSHEAD AND PIN

The crosshead as shown is of box section made of cast steel having a high tensile strength. The top shoe is cast integral with the crosshead casting and has a full babbitt face on top. The bottom shoe is made of solid bronze and is wedge adjustable. After adjustments have been made the shoe is bolted rigidly to the crosshead making it impossible for the shoe to become loose.

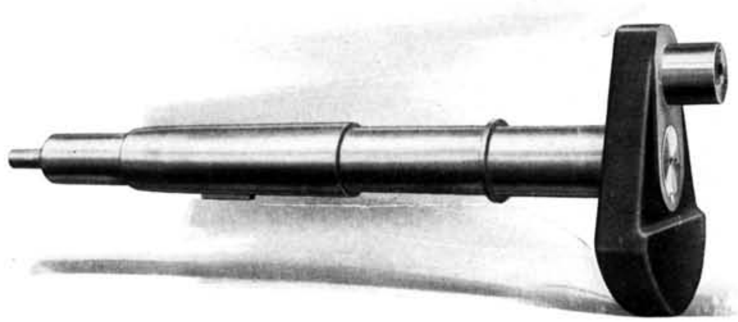
The crosshead pin is of hard cast iron made hollow (which prevents any shrink holes in the casting) with a flange on one end. It is forced into taper seats at both sides of the crosshead and may be easily removed without the use of a sledge. The pin may be given one quarter turn when worn, thus providing a new wearing surface.



Cross Head and Pin

CRANK SHAFT

The crank shaft is made from a solid forging of open hearth steel of .35 to .40 carbon and is provided with a heavy crank designed to secure proper counterbalance. The crank pin is of very liberal proportions and cast integral with the crank. This construction is to be preferred to a crank having a pin pressed in, as there is no possibility of a loose crank pin and the chances of the crank becoming loose on the shaft are entirely eliminated due to the fact that the crank has but one hole bored through it, which fits to the shaft.

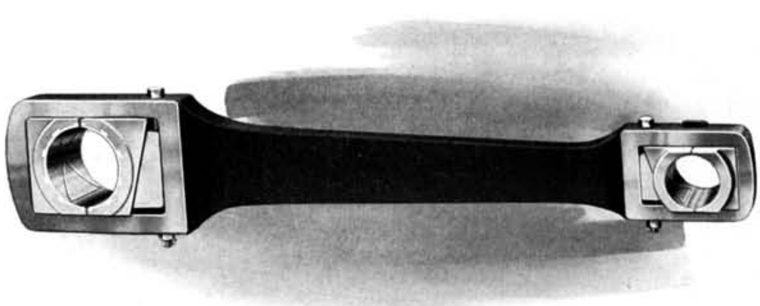


Crank Shaft and Disc

If the crank pin is pressed into the crank it becomes necessary to bore two holes through the crank and when the shaft and pin are both pressed into these holes, the metal in the crank between these holes is very liable to become stretched beyond its limit of elasticity and loose crank pins or loose cranks are the result. There is no case on record of a broken crank pin, or no record of a crank becoming loose on the shaft of any Ames Engine of the Side Crank type of which there are now over two thousand in operation. This, we believe, is a record not attained by any other builder with an equal number of engines in operation. Crank discs of 27 inch stroke engines and larger sizes are made of cast steel, smaller sizes are made of semi-steel.

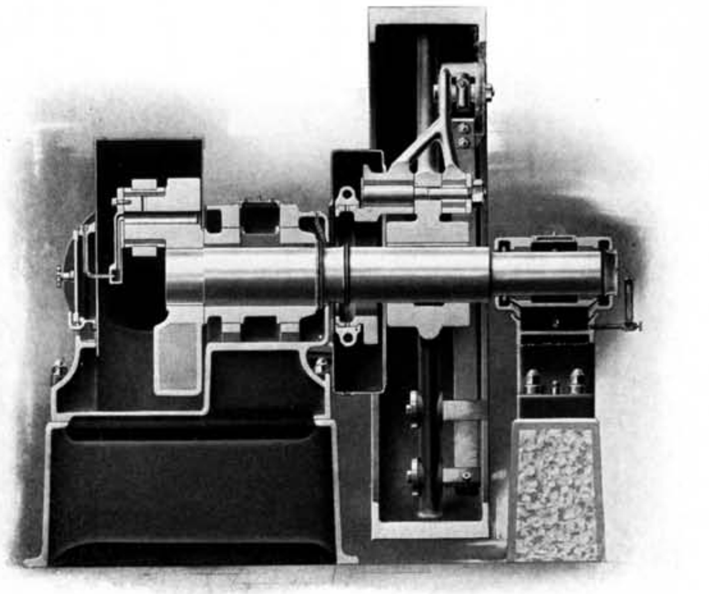
CONNECTING ROD

The connecting rod is forged from high grade forged open hearth steel mortised at both crank and crosshead ends to receive the crank and crosshead boxes. These boxes are made of cast iron, lined with genuine babbitt on the small sizes, while on the larger sizes the crosshead boxes are made of bronze and the crank boxes are cast steel with genuine babbitt lining. The boxes are so constructed as to allow their removal without removing the connecting rod from the engine. The connecting rod is of rectangular section and being a solid forging is very rigid and far superior to rods constructed with strap ends.



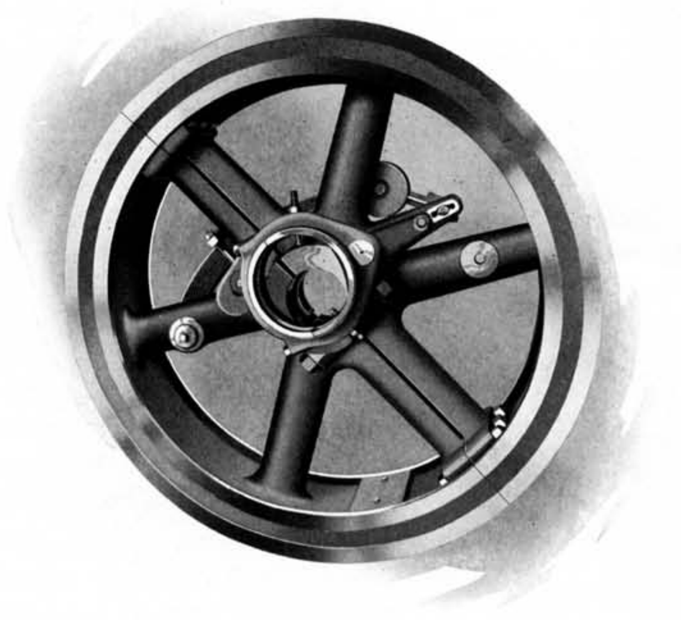
Connecting Rod

GOVERNOR



Section Through Bearings and Governor

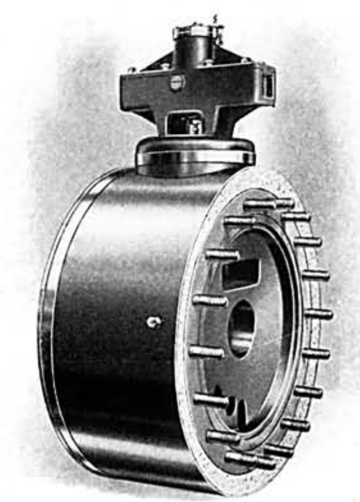
The improved Robb-Armstrong-Sweet governor as built by us is a perfect regulating device. It is the simplest type of shaft governor, is of rigid and durable construction, and stable in operation under all conditions and service. Our long experience with shaft governors has shown us that an eccentric lever with a single bearing will not carry the heavy weight of the eccentric and strap (regardless of the type of bearing used) without proving more or less troublesome. For this reason we use an eccentric lever having a double bearing, each bearing having double bushings, the inside bushings being of the revolving type. This construction assures perfect alignment of the eccentric at all times and prevents the eccentric and strap from wearing out of line or running hot, and gives a smooth running strap. These improvements were patented and used exclusively by ourselves.



Governor (Eccentric Side)

PISTON AND ROD

The piston is a hollow casting heavily ribbed on the inside making it light and at the same time very strong to withstand the work required of it. All pistons are long enough to keep the central exhaust ports closed until within approximately 10% of the end of the stroke when the ports are uncovered and exhaust occurs into the central exhaust belt, which encircles the cylinder from which direct communication is made with the exhaust pipe or condenser connection.



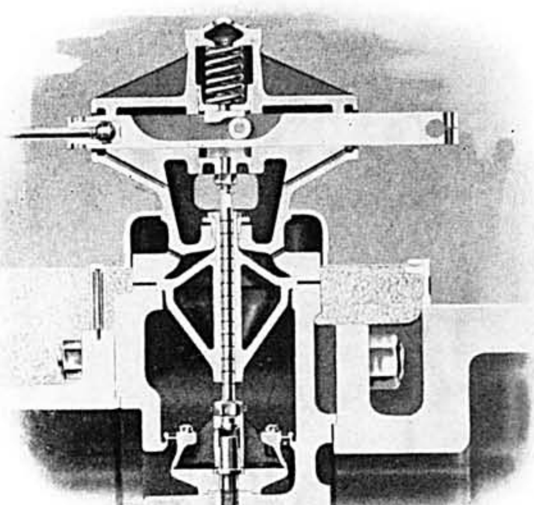
Cylinder Head and Bonnet

The pistons are all fitted with six (6) spring rings and the larger pistons have unless tail rod is used in addition to the spring rings two (2) rings of anti-friction metal.

The larger engines (and smaller ones when so ordered) are equipped with a tail rod guide attached to the outside cylinder head and supported by a cast iron support. This casting has bored guides and fitted with a crosshead so that the piston is made to float in the cylinder, the weight being carried by the two (2) crossheads on a piston rod of large size made of open hearth forged steel.

CYLINDER HEADS

The cylinder heads are made of hard, close-grained iron of the same mixture as the cylinder casting and after being roughed off, by having the outside scale removed from all the finished surfaces, are annealed so that all internal casting strains are eliminated.

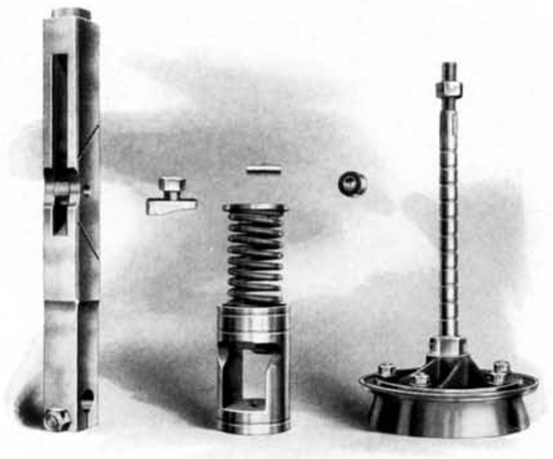


Section Through Bonnet and Valve

The heads contain the steam admission valves with the steam-port, which is very short and direct, admitting the steam into the cylinder as near the center of the end of the piston as possible. This construction eliminates any possibility of wire drawing the steam through long, indirect, or restricted ports and passages after leaving the throttle. The heads are lagged with magnesia lagging of sufficient thickness to insure proper insulation and this is covered with a smooth sheet metal casing, secured to the head in a manner that makes it unnecessary to disturb the magnesia lagging when removing the cylinder head.

BONNETS AND VALVES

Steam is admitted to the cylinder by a double beat poppet valve of special construction (to insure steam tightness) which is lifted by a roller in a square section sliding bar when it comes in contact with the lifting cam, which is carried in a small cylindrical bronze crosshead attached to the valve stem, and the valve is closed by the coil spring on the top of this crosshead, the top of the spring bearing against the bonnet cap.



Roller Rod, Cam, Roller and Pin, Valve Crosshead, Spring and Valve with Stem

The sliding bar, which carries the roller, being of square section insures the roller at all times coming squarely in contact with the cam, as any adjustment made to the valve gears cannot affect the alignment of these parts, which is a marked improvement over this type of gear in which a round type of sliding bar is employed.

The bonnet is made in two parts, which makes adjustment possible, to compensate for any wear on the sliding bar or bonnet. However, the wearing surface is so large in comparison to the load of lifting the valve that the wear on these parts is almost negligible.

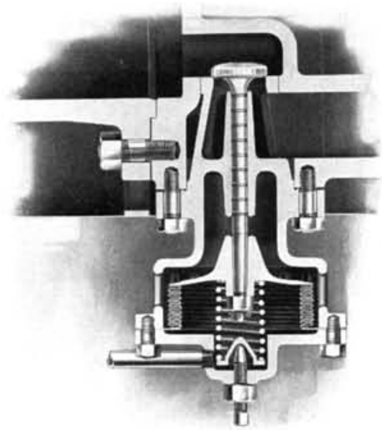
The admission valves being of the double beat poppet type with the upper seat flexible insures the valve always remaining tight; they are lifted in perfect alignment with their seats, so that with the engine operating at maximum cutoff, the valves and cams are practically noiseless. The valve stems operating through long sleeves make it unnecessary to provide any other steam packing for them.

AUTOMATIC BY-PASS VALVES

Engines which are furnished for condensing operation are equipped with the automatic by-pass valves as shown in section, to prevent undue compression in the cylinder due to loss of vacuum. These valves are entirely automatic in operation, are controlled by the condition existing in the exhaust belt of the engine, and operate only with loss or restoration of vacuum and *do not operate* at each stroke of the engine. The small pipe is connected with the exhaust belt or exhaust pipe of the engine, thus communicating the conditions existing in the exhaust belt to the sylphon, which is attached to the valve stem.

By the action of the vacuum the sylphon is collapsed, the coil spring compressed, and the valve held firmly at all times to the seat, which reduces the clearance to secure proper compression for condensing service. If the vacuum is partially or totally lost for any reason whatever, the spring will open the valve which communicates a clearance pocket in the cylinder head with the clearance in the cylinder, which increases the total clearance volume and thus prevents undue compression during non-condensing operation. When the vacuum is again restored, the valve closes as above described.

The tension on the spring can be changed by the adjusting screw so that the point at which the valve opens and closes can be varied to a reasonable extent. With this construction there are no mechanically operated parts, no additional valve gear, the ordinary water relief valves are not depended upon to relieve compression. The valve and stem are one piece of hammered steel and the stems operating through long guide sleeves require no packing. The sylphon prevents any possible leakage of vacuum, which is sure to occur where the vacuum must act upon the end of an oscillating shaft. It also eliminates the friction which prevails in this type of valve where a piston and cylinder are employed.

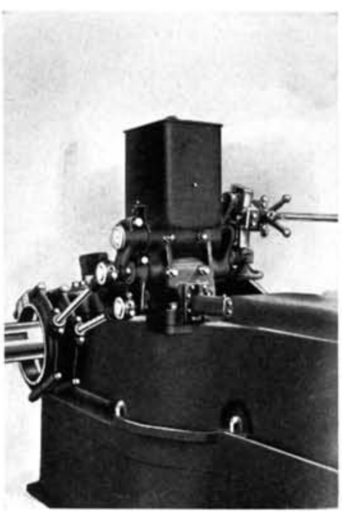


Section Through By-Pass Valve

The oblong openings in the sylphon housing permit observance of the sylphon at any time and its instantaneous action with loss or restoration of vacuum can easily be seen. This mechanism is of the simplest possible construction and is covered by U. S. letters patent and used exclusively by ourselves.

VARIABLE SPEED VALVE GEAR

There are several different classes of work for which the Una-flow Engine is desirable due to its high efficiency and extreme simplicity, but which also requires some means of changing the speed of the engine while in operation without materially affecting the economy. This class of work is ammonia compressor drive, centrifugal pump or work of similar nature, and we believe we are correct in stating that there are more Ames Una-flow Engines in operation, direct connected with ammonia compressors, than a any other make of Una-flow Engine in the same service. We also state beyond any reasonable doubt that a greater tonnage of ice is being manufactured per ton of fuel than with any other make or type of Una-flow Engine built.



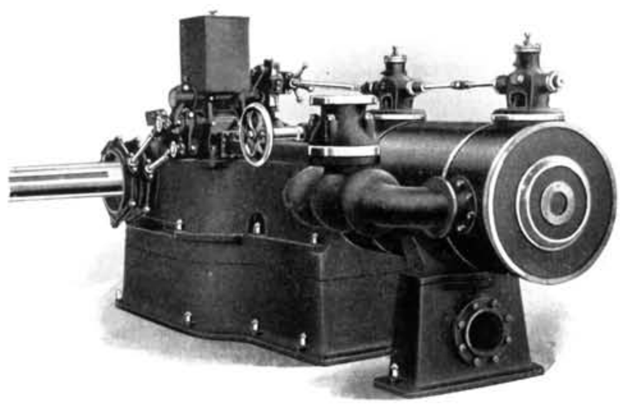
Variable Speed Valve Gear

This constant demand for Una-flow Engines for this kind of work is responsible for the development of our Variable Speed Valve Gear, which we are prepared to furnish on any size of Una-flow Engine when so desired.

The design of this gear is also unique and the construction and operation is very simple indeed, the same steam distribution being obtained at all speeds as would be obtained if the engine was operating at the same point of cutoff and at full speed with shaft governor control.

A shaft governor, however, is always furnished and is a part of the variable speed gear. This governor acts as a limit stop so that, were the load suddenly thrown off (as in the case of a centrifugal pump losing its suction water) the engine will increase in speed until the maximum or predetermined governor speed is reached and then continue to operate at this speed until shut down or load is again applied.

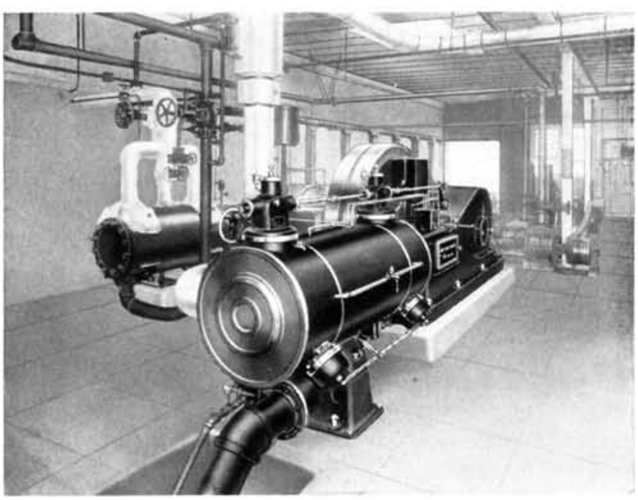
We have built units with variable speed valve gears in sizes from 50 to 1000 horsepower, and any prospective purchaser will profit by investigating this variable speed gear. The range of speed obtainable is not limited as is the case with engines where the variation in speed is obtained by adjustments of the governor (lay shaft type), but with the Ames variable speed valve gear the engine may be brought to a stop with the throttle open and full steam pressure in the steam passage leading to the valves and ports.



Engine Equipped with Variable Speed Valve Gear

SYNCHRONIZING DEVICE

We have made a great many installations of Una-flow Engines direct connected to alternating current generators where two or more are operated in parallel, which installations have proven very successful indeed. However, it is sometimes desirable to have the units so arranged as to enable the operator in charge to increase or decrease the speed of one or more of the engines while they are in operation, thereby transferring a portion of the load from one unit to another. Engine builders have devised various means of accomplishing this result, and while some of the devices used have proven more or less successful, there has been some objection to their use due to the effect which such devices produced upon the regulation and also because of the complicated and unreliable mechanism furnished for accomplishing this speed change.



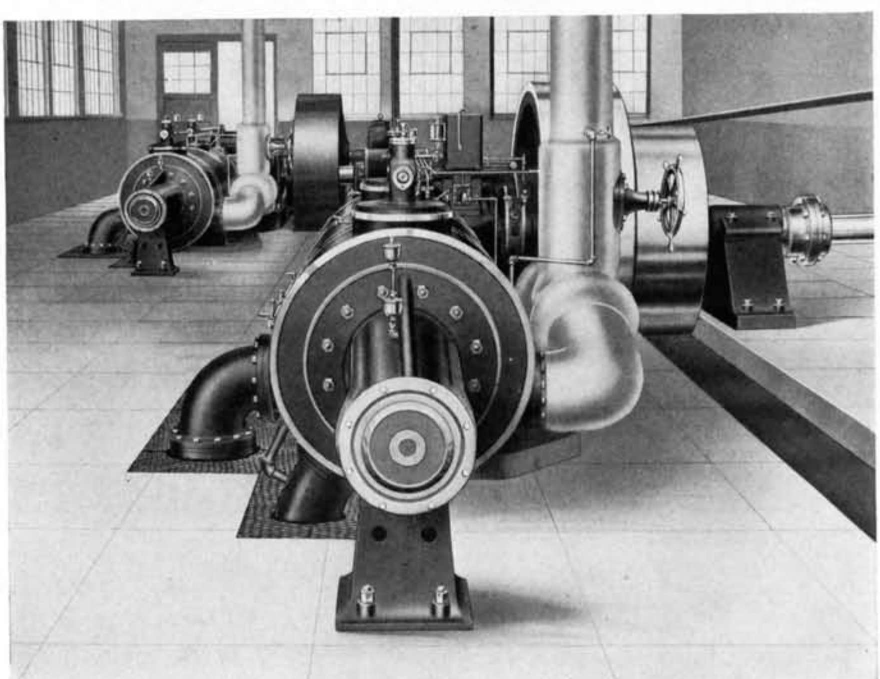
Una-Flow Engine D. C. to Ammonia Compressor

We have designed what we believe to be the most unique, most compact, and simple arrangement for successfully accomplishing this result, that is to be found on the market. This device consists of a casting made in two parts and bored to fit the engine shaft and mounted upon the shaft adjacent to the governor wheel hub on the generator side. Upon this casting is mounted a small, fully enclosed, reversible motor connected through gearing to a small eccentric shaft. The eccentric is connected to a rod, which is forged into a loop at one end forming a fulcrum point on an auxiliary spring, this auxiliary spring being so arranged that the tension is exerted at the same point as the main governor spring.

Collector rings are mounted on the shaft at the outboard bearing end and suitable brush rigging is mounted upon the outboard bearing. Wire connections are made between the collector rings and the motor A double throw spring switch is provided for the switchboard. By throwing this switch one way the speed of the engine will gradually increase and by throwing it to the opposite side the motor will reverse in rotation and the engine speed will gradually decrease, thus the desired speed is obtained. When the operator lets go his hold on the switch, it automatically springs back to a neutral position avoiding any possibility of leaving the motor in operation.

It is understood that the main governor spring controls the speed as with the ordinary governor, and the variation is obtained by varying the tension on the auxiliary spring. The use of the auxiliary spring is superior to attempting to secure the same results by changing the position of or the adjustment of governor weights.

We have built these devices where a variation in speed of thirty-five per cent was obtained without in any way affecting the regulation, but this wide variation is not usually required, as a variation of five per cent is about the maximum that is required.



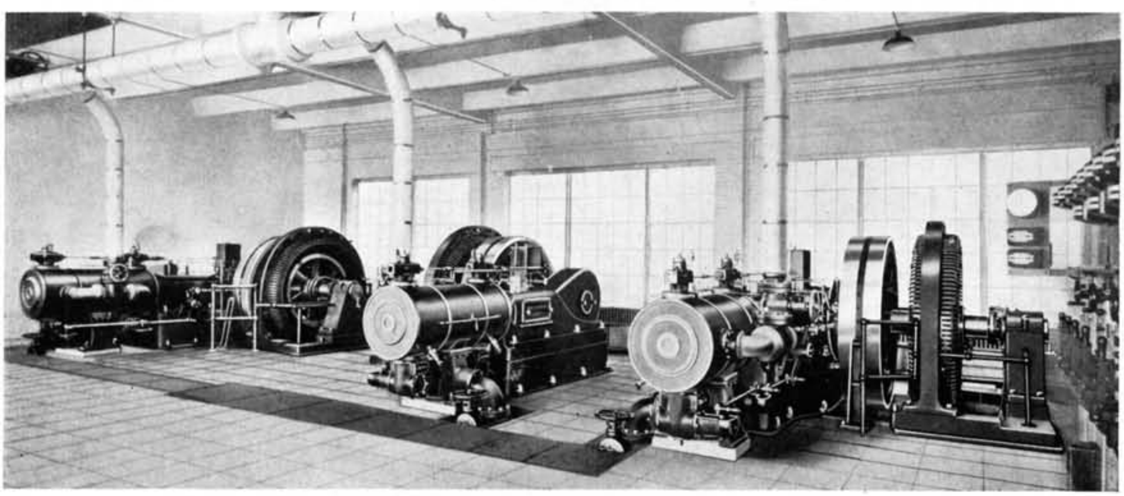
Two 1000 H. P. Una-Flow Engines in Rubber Mill

THE CONTROLLED COMPRESSION UNA-FLOW ENGINE

THE assumption has been that it was not possible to obtain excellent results in steam economy operating non-condensing with other than high initial pressures and atmospheric exhaust, and often it has been stated that because an engine is to exhaust against five or ten pounds back pressure, it makes little or no difference what the efficiency of the engine is; however, it is very seldom that this is the real fact. There is always more or less heat loss by the reduction of pressure and by transmission through any type of engine, or turbine, that is of no value to the exhaust steam as this lost heat does not reach the exhaust except in form of condensation, and therefore if the cylinder efficiency is high and internal cylinder condensation eliminated to the fullest possible extent, the great heat loss that prevails in the ordinary counterflow engine cylinder does not occur when the una-flow principle is involved.

There are many manufacturing plants that require only a small or moderate amount of steam at low pressure for heating, drying or other purposes, and where for obvious reasons steam must be furnished at pressures and temperatures the equivalent of anywhere from two to fifteen pounds pressure. Therefore, to obtain the highest possible overall efficiency, a place is created for a reciprocating engine that will operate economically over a wide range of pressure and temperature conditions, and show far better results in steam economy than has ever been accomplished with the usual design counterflow engine.

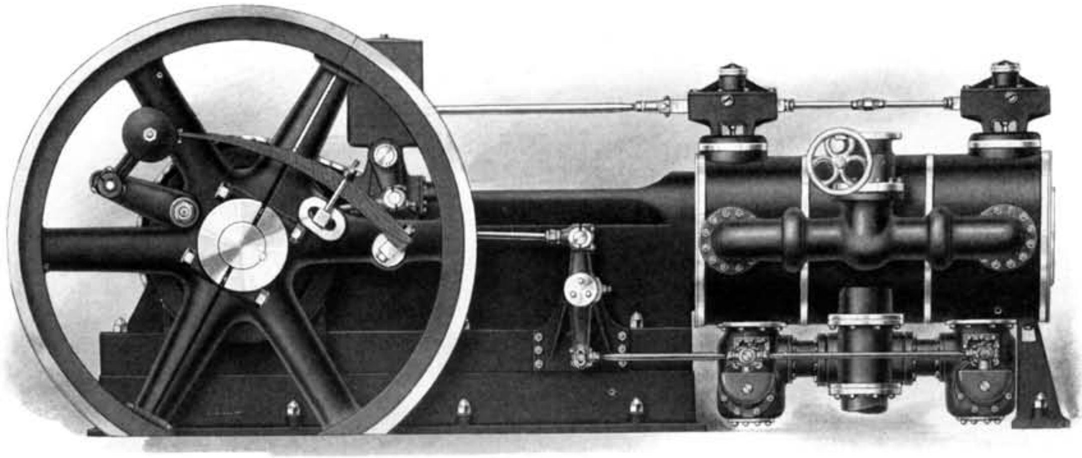
However, in many instances, owing to these widely varying pressures, the conditions are not advantageous to an engine of the two-valve type, operating on the full una-flow principle having from 85% to 90% compression. In many cases a single cylinder two-valve engine, with its necessary large cylinder dimensions and heavier driving parts, would be such that good engineering would not admit of its operation at the necessary high rotative speed. It is, therefore, obvious that the most flexible and economical reciprocating engine for operation under medium, low and varying pressures should have somewhat *delayed* and *controlled compression*, if the engine is not of the multiple cylinder construction.



Industrial Installation of Three 250 H. P. Controlled Compression Engines

To accomplish these results, maintaining the necessary una-flow principle, and to meet the frequently prevailing extreme pressures and varying conditions, for the production of maximum economy, we have developed and perfected the Ames Controlled-Compression Una-Flow Engine. The construction of this engine, for other than dual exhaust, is identical to the Ames Una-Flow Engine of the two-valve type illustrated and described herein.

Adhering to the una-flow principle, as in the Ames Two-Valve Una-Flow Engine, the steam after admission to the cylinder flows forward with the movement of the piston, and at the end of the stroke the wet expanded steam passes out through the central exhaust thereby preventing additional condensation by its return to the hot ends of the cylinder, washing and cooling the clearance surfaces. Therefore, the compressed steam on the return stroke is that of the dryest steam remaining in the cylinder after final exhaust closure.



Governor and Valve Gear Side of Engine (Note Straight Line Drive Valve Gear)

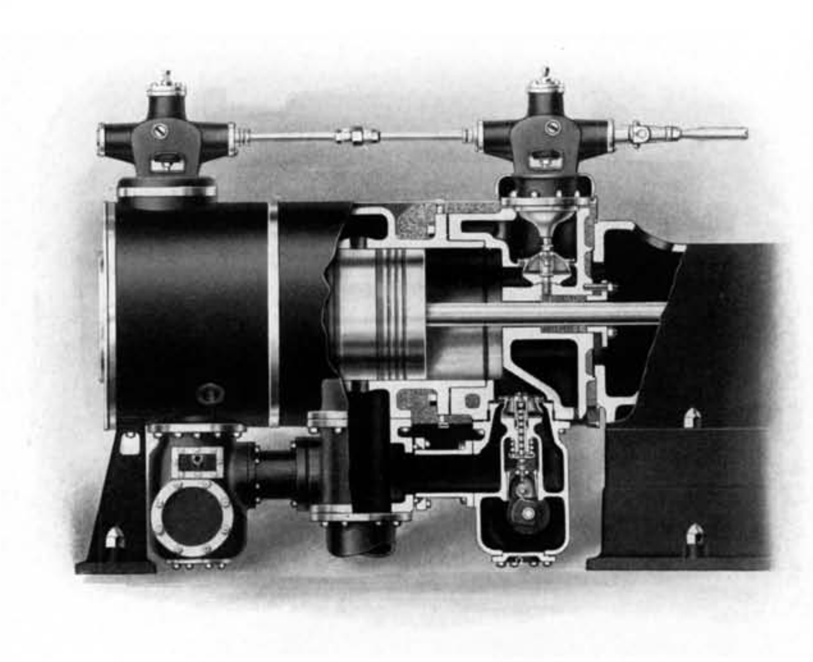
The cylinder heads are provided with steam jackets which also entirely surround the cylinder bore at the ends and are extended longitudinally to approximately normal cut-off. A baffle cast in the cylinder heads directs the steam flow in the cylinder and head jackets in such a manner that perfect circulation of the jacketing steam is obtained.

The secondary exhaust ports and valves are located directly at the ends of the cylinder so that the final exhaust closure is not controlled by the piston covering the secondary exhaust ports. This construction permits of the compression being *controlled* at will, it being possible to vary the time of final exhaust closure to such an extent that ideal compression pressure may be obtained under widely varying admission and exhaust pressures. This is, of course, quite impossible in any design wherein the final exhaust closure is accomplished by the piston cutting off communication between the cylinder and exhaust chamber, as the location of the secondary exhaust ports or the length of the piston cannot be changed to alter the time of final exhaust closure, *necessary* for widely varying initial and back pressure conditions.

The compression pressure may be varied for different initial and back pressure by the simplest valve gear adjustments within a few minutes, thus making it possible to obtain the highest possible economy at all seasons of the year, in the event high initial pressure with atmospheric exhaust prevails at one season, and medium or low pressure with back pressure is the condition for another season.

EXHAUST VALVE GEAR

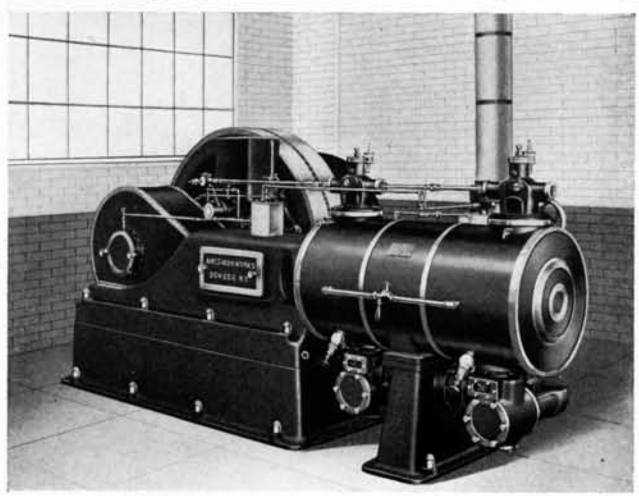
Not only is the valve gear sufficiently flexible to cover non-condensing operation under conditions referred to, but it may be so adjusted as to permit of perfect operation with the engine exhausting into vacuum, although in this case the economy is somewhat impaired to that of the Ames Una-Flow Engine of the two-valve type.



Section Through the Admission and Exhaust Steam Passages

The secondary exhaust after passing through the valves and bonnets is directed to the central exhaust chamber under the cylinder through the connecting pipes, thereby avoiding contact with the outside of the cylinder barrel, and cooling the cylinder on its way to the main exhaust chamber.

The exhaust bonnets are so constructed that the exhaust steam does not come in contact with the oil bath which submerges the cams, rollers or valve stem crossheads, and any condensation that follows the valve stems into the oil bath is separated and trapped off by a U-tube arrangement furnished on each bonnet. The cam shafts operate in brackets filled with oil submerging the cam shaft bearings, making the usual grease cup lubrication unnecessary.

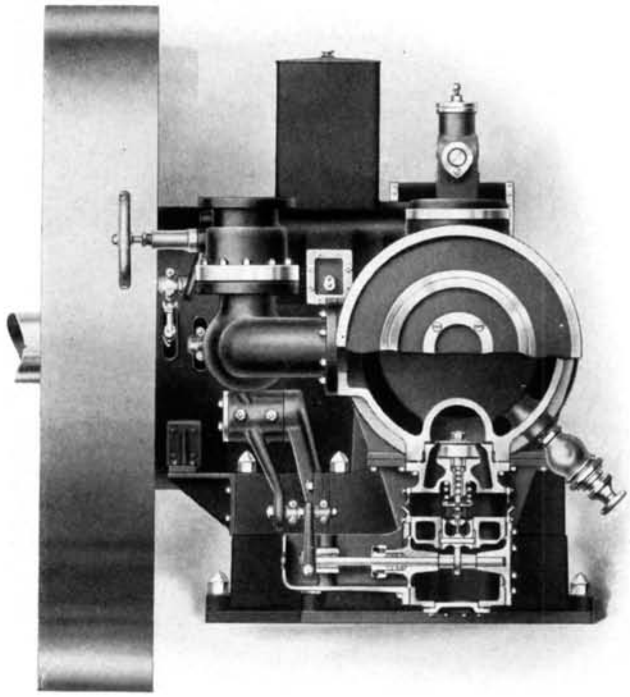


Controlled-Compression Una-Flow Engine Direct Connected with 100 K. W. Direct-Current Generator

By referring to halftone on preceding page, at first glance, the straight line drive valve gear will be noted on both the admission and the secondary exhaust gear, which is particularly desirable as angular thrusts are eliminated entirely on the valve gear bearings, levers and cam shafts, with the result that the forcing of grease to the different bearings for their quiet operation is in this case quite unnecessary.

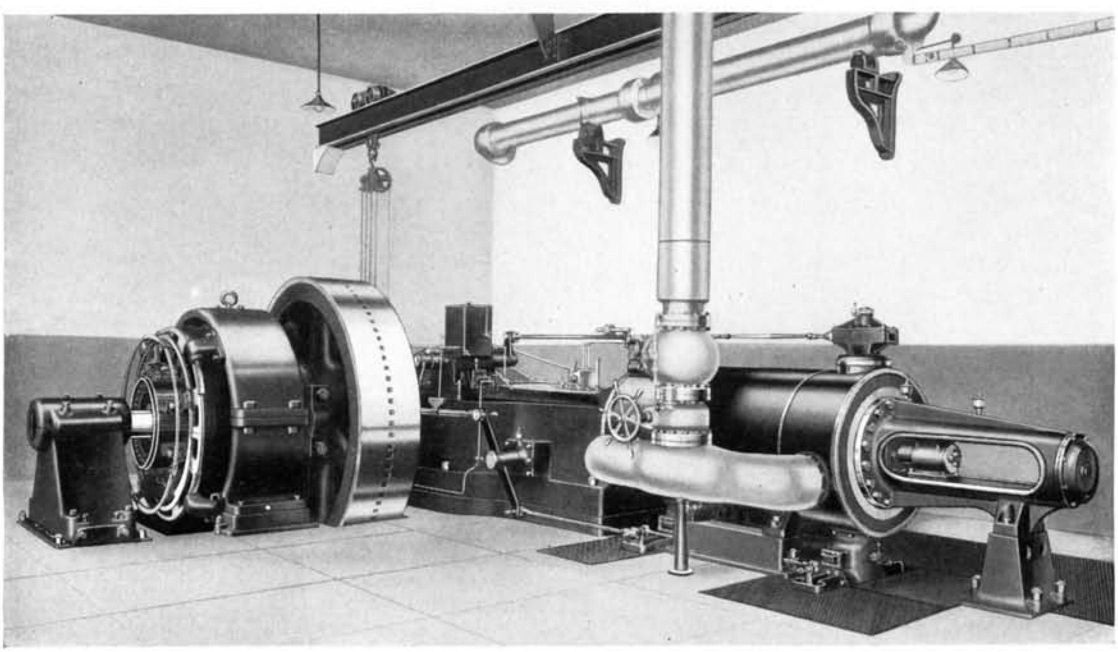
In construction and operation the similarity of the complete admission and secondary exhaust valve gear will be' noted, the admission valve gear being identical to that so successfully used for a number of years on the Ames Una-Flow Engine of the two-valve type. The exhaust valves are lifted by oscillating cams rigidly attached to the cam shafts, lifting against the hardened ground rollers carried in the vertical circular cross-heads.

By careful reference to the operation of these secondary exhaust valves, it will be observed that they are opened at a time when there is little or no pressure on them, and that for a period of ten per cent. of the stroke, or when the piston is returning to cover the central exhaust, they are subject to absolutely no pressure. Consequently during this period the valve gear adjustment may be such that it will lift the valves off their seats with no load other than the spring pressure which holds them down.



Section Through the Secondary Exhaust Bonnet and Valve

As the valves, however, are of the double beat poppet type, almost in perfect balance, they may be lifted from their seats by hand (with the valve gear disconnected)



The Ames Controlled-Compression Una-Flow Engine Direct Connected with 300 K. W. Direct-Current Generator with little or no effort with full operating pressure holding them on their seats in addition to the spring tension. This would not be possible with any single beat valve in the event piston steam leakage or other causes permitted pressure to build up on the valve head.

LUBRICATION

Lubrication of the piston and cylinder is provided by a mechanically operated cylinder lubricator of large capacity with sufficient feeds to connect to the throttle valve as well as the cylinder. A small amount of oil is fed through the throttle to sufficiently oil the throttle and valve stems. The oil for the piston and cylinder is fed direct into the cylinder through the feeds connected to the cylinder barrel.

The main bearing, crosshead, crosshead pin, rocker arm shaft and eccentric are lubricated from the automatic oiling system furnished on all engines.

This system consists of an oil tank of large capacity equipped with a filter to cleanse the oil as it is pumped back by the rocker shaft oil pump from the crank pit, where all the oil drains after lubricating the several parts, thus the oil is used over and over again and at the same time is free from any foreign matter which would cut bearings or journals.

The governor pins and the three joints of the valve gear are lubricated by large size spring compression grease cups. The outboard bearing is lubricated by non-magnetic rings or chains which carry an abundant supply of oil from the reservoir in the pedestal casting up to the shaft journal. The lubricating system used on the Ames Una-flow Engine is simple and very efficient, the storage capacity for oil is large which is assurance that all parts will be properly lubricated. The crank and eccentric are encased with an oil guard which completely covers these parts.

OVERALL EFFICIENCY

The highest possible overall efficiency is obtained only by using the Ames Una-flow Engine, as the steam consumption per horsepower hour is practically the same at all loads. This will be seen by referring to comparison curves shown on page 14 showing the steam consumption curves of various types of counter-flow engines and a curve from an Ames Una-flow Engine operating under the same conditions. The unusual economy of the Ames Una-flow Engine can be partially attributed to the double beat poppet valves used with which numerous tests have been made and proven beyond any doubt that these valves are so constructed as to be steam tight, and remain steam tight, thereby maintaining the original economy of the engine.