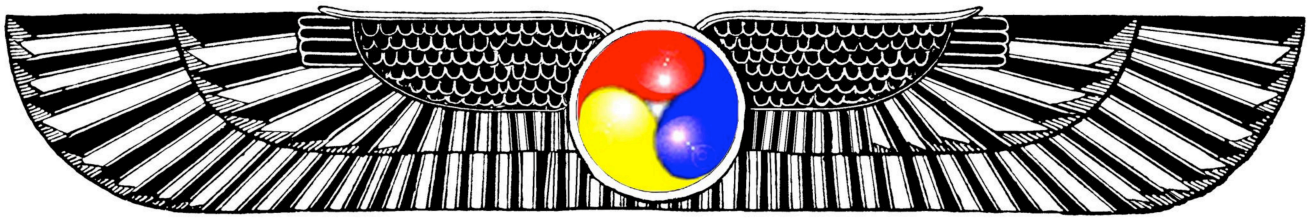


Sympathetic Vibratory Physics

The Keely Motor

or

Hydro-Vacuo-Pulsating Engine

– How It Works and Why –

John W. Keely
Clara Sophia Jessup Bloomfield-Moore
Dale Pond

"My system, in every part and detail, both in the developing of this power and in every branch of its utilization, is based and founded on *sympathetic vibration*. In no other way would it be possible to awaken or develop this force, and equally impossible would it be to operate my engine upon any other principle."

John Keely, 1888

John Ernst Worrell Keely

Introduction

John Ernst Worrell Keely began his great work with the development of the Hydro Vacuo Engine in the 1860s. His original patent on this motor is included in this book. The drawings are from his first patent and only remotely resemble the later machine designs. It is reported that he eventually built 129 models of this engine in an effort to perfect it for production and sale to the general public. In later years he is said to have given up on the idea of using the forces generated in this motor as a motive power source. It is further surmised that the motor now in existence is one of the later versions of this motor. The design is clean, efficient and as well engineered as we are able to define its functions. It is this perfected model that we were able to rebuild and run.

The Keely Motor, subject of this book, was donated to The Franklin Institute some time in the 1920s or 30s. There the motor sat until 1946 when Victor Hansen made an offer to the the museum to buy it. It took him 10 years to pay for it allowing him to take it home. Since that time he has cared for this machine and made no attempt whatsoever to work on it for fear of damaging its delicate construction and mechanism. As a result of the care given this motor first by its donor, the museum and then by Mr. Hansen, it has survived in almost perfect mechanical condition.

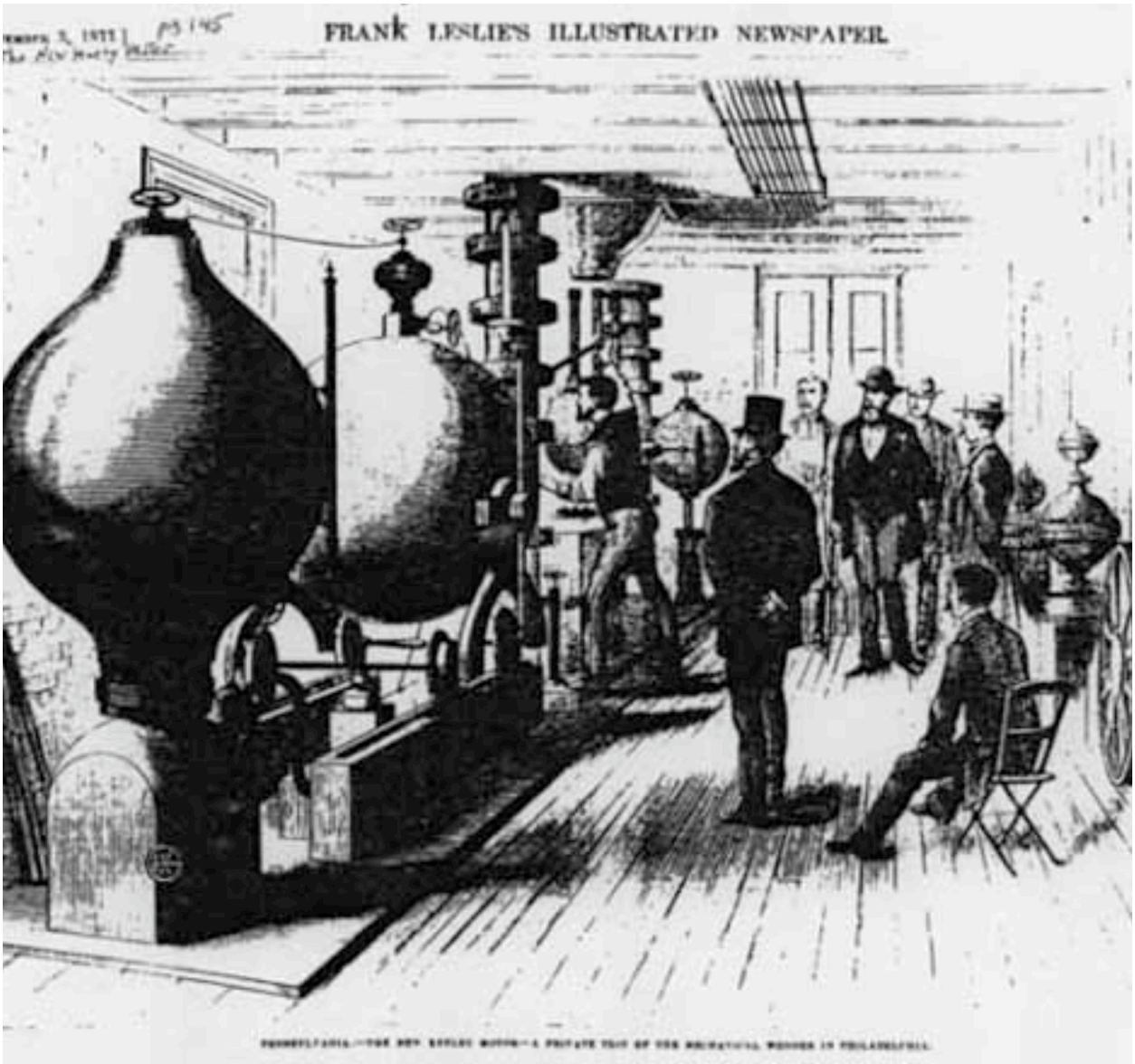
Victor Hansen, owner* of the machine, and Dale Pond, editor of *The Journal of Sympathetic Vibratory Physics*, spent the better part of a week in August, 1990 rebuilding this motor. The motor has two valve assemblies, and two power pistons. One of the check valves on one of the pistons was none functional which did not allow full operation. The refurbishing effort succeeded in making only one of the two sides operate. Hence, the machine was not operating at full capacity and was not able to produce enough power to pull itself. However, one piston and valve assembly functioned enough to demonstrate the principle of power development Keely used to run the machine.

The motor gets its power from the cavitation (implosion) or water hammer of a small stream of water passing through its valve assemblies and into the pistons. All the components of this motor were superbly engineered and manufactured to insure the maximum velocity of the stream and optimization of the cavitation process. Cavitation results from the cutting off of a flowing stream of water. The higher the pressure of the water and the faster the shut off time increases the degree of cavitaiton. The power results from the cavitation bubble collapsing. This force then is not an *explosion* but is instead an *implosion.*

Cavitation creates a vapor usually referred to as *cavitation vapor* of which there are several types. This vapor is the very same as Keely's Etheric Vapor. With the further study, developmet and application of this vapor he was enabled to develop his "higher level" devices. It has been claimed that these later devices were able to develop as much as 100,000 psi in a fraction of a second thus powering his Etheric Vapor Cannon and the many demonstrations of this pressure using a hydraulic lift. It is hoped those so inclined to work in this extremely fertile and undeveloped field will study, develop and apply it in the near future.

Included in these pages are progressive drawings of the valve and piston assemblies of the Keely Motor. Review of these drawings will reveal quite plainly how they work together to create the flowing stream of water and its subsequent cavitation. How Keel was able to develop hugh pressues instantly is beyond the scope of this book.

Dale Pond
(revised 5/8/06)
including additional photographs
* see section "Keely Motor Stolen"


FRANK LESLIE'S ILLUSTRATED NEWSPAPER

The Keely Motor Stolen

Victor Hansen, Alchemist

My recent road trip was for the primary purpose of visiting with my long time friend and fellow Keely enthusiast, Victor Hansen. I've known Vic since about 1987 or 1988. He is currently confined to an elderly care facility in rural Iowa. How he came to be there (aside from his age of 84) is a story of monumental proportions and is vitally important to the rest of us. Over the next few weeks I hope to write his full story. His life is an inspiration and filled with wisdom. In the meantime here is quick synapsis.

The last time I saw Vic was in 1999. I was in process of relocating from Oklahoma to Colorado and I wanted to see how he was doing, in general. A few years earlier Vic had been living in his parent's home in downtown Dike, Iowa. His grandfather helped settled the town and his family had been an integral part of that community ever since. Now (1999), however, Vic was living in a run-down farm house several miles from town and in the middle of a corn field, sometimes planted to soybeans. My stays with Vic have always been pleasurable, relaxing and always educational.

This trip was initiated by a phone call from Vic - something he has never done before as he did not have a phone. Actually it was a nurse who placed the call. Vic said all his stuff was gone and he wanted to see me - soon. As I was coming up from the south it was logical to stop at the old farm house and see what the situation was concerning his "stuff". Imagine my shock to see not only was his stuff gone but the house too - now planted in soybeans. Not a trace of Vic, his stuff or any sign that he had ever been there. Vic had packed the house with antiques, rare books, nick-nacks, the Keely Motor, an immense collection of old electrical devices and of course his decades old efforts with alchemy - making gold. (The real purpose of alchemy is the perfecting of one's soul!) He had packed the barn with old mechanical and electrical devices too. Now, all gone - not a trace any of this stuff or Vic ever existed. But I had seen it many times and knew then this trip was important.

On seeing Vic, sitting in a wheelchair, a broken hulk of his former self I did not recognize him. Try as I may I was not able to recognize a single physical feature save his size and his voice. Who could ever forget Vic's voice? He however recognized me and gave me his usual warm and sunny welcome - though it was a bit subdued. Vic is a giant of a man - well over six feet and probably weighed 250 or more pounds. Now he was thinned down to maybe half that, gaunt and stressed. I've often described Vic to others as a "giant Teddy bear". Gentle, pleasing, filled to overflowing with wisdom, without a single mean bone in his considerable body.

Vic launched into his story. Tears from both of us rolled down our cheeks.

Some time ago (I didn't get dates) he was arrested on trumped up charges of child molestation. He had the usual insane ordeal with the insane courts. Then he was sent to prison. Two or three months in one prison then transferred to another "hardened" prison for another two or three months. This man was at that time over 80 years old! The details of his stays sound like an Edgar Allen Poe horror story. I'll leave these for the more detailed story to follow later.

When he was abruptly released (without warning or notice!) he found his way back to his home only to discover it had been ransacked, trashed and a complete mess. He said the mess was so great he couldn't tell what was still there and what had been stolen. The very next day his landlady serves him with an eviction notice saying she could no longer protect him or provide security and that he must have strange friends who could do this to him and his property. I don't have a good timeline but it must have been that day that Vic, driving his pickup and all doped up

from the "sleeping" pills given him by the prison, crashed into another pickup pulling a trailer. He broke four vertebrae, severed his thumb off and dislocated his left shoulder. Vic woke up swinging beneath a rescue helicopter.

His thumb was reattached and his neck is now permanently frozen in the forward position. He is in reasonably good mental and emotional condition - considering his entire life has been erased.

So Vic's lifetime of studying alchemy, Keely, science and philosophy is gone. His antiques, books and collection of old electrical devices gone. Someone from a neighboring town had stepped in claiming to be his relative and sold off everything, stealing much and kept all proceeds for himself. Another person aided in this looting of a gentle and loving friend of humanity. Vic loved Keely as much as he loved God of whom he always spoke in loving terms.

The thing that tears (pun intended!) me up the most is Vic's eyes. Never have I seen such eyes! The pain, agony, appeal for love and hope, his lost life's ambitions and possessions burned from deep in his soul. Those eyes are forever burned into my memory!

During the telling of this story which took all afternoon neither of us could hold back the tears. The horror of it, the sense of persecution and betrayal he must have felt. The sense of hopelessness he was not able to fight back. His gentle side did not prepare him for fighting back - he didn't know how. Wrenched from his house and thrown into a maelstrom of horror, abuse, neglect, mistreatment, loneliness and all the rest. Only to finally return home to find his life trashed. My mind went into this vicarously and I think the only thing that saved me was the realization that this was Vic's chosen experience - not mine. I had to wall it off.

So what were the theives after? The Keely Motor? His antiques and books? Or were they after his gold-making formula? Or were they just seizing an opportunity to enrich themselves at Vic's expense? Was it just neighborhood hoods? Or were they covering for something more sinister?

The second day visit I asked Vic for some of his wisdom. He was able to quote many things which I wrote down and will share with you later. Such a mind he has! Such wisdom mostly unappreciated by the uninformed and ignorant. Vic has been a teacher for me all these years. No other ever came even close. Here is one of his priceless pearls of wisdom:

God is an ECI.
God is an Eternal, Creative, Intellect.

A reward is being offered of $1,000.00 for the return of the Keely Motor or information leading to its return. Victor Hansen, owner of the motor for over 50 years, affirms the motor was taken/stolen from him and it is now considered stolen property. This offer is not to persecute or bring harm to anyone. This offer is solely for the return of the motor to its rightful owner - no questions asked. Anyone having information concerning the whereabouts of this motor is asked to contact Dale Pond, holder of Mr. Hansen's Power of Attorney and authorized to seek its return. Your identity will be strictly honored and held private. You may contact us anonymously if you wish.

Dale Pond
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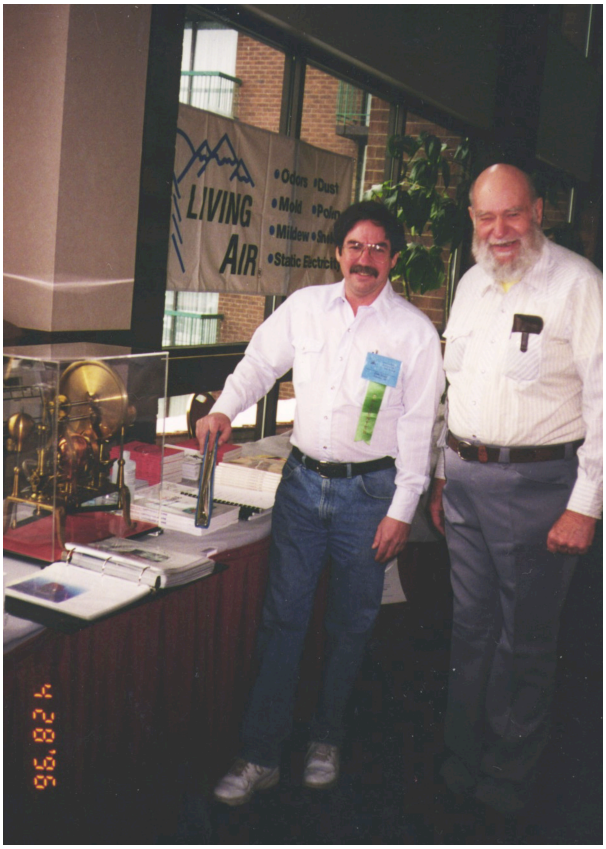


Pond & Hansen, 1996

Hansen & Pond, 2004

The Keely Motor
Implications on Society

The Keely Motor operates using the principle of cavitation of a flowing stream of water. Cavitation is initiated and maintained by mechanical action and not by heat or chemical forces. The implications of this on society will be dramatic.

First, since it does not use a "chemical" fuel the chemical industry will be financially negatively impacted, especially the petroleum industry.

Second, it uses ordinary water, a renewable resource and the water it does use is not destroyed but returned to the environment. This recycling of water instead of dumping polluting chemicals will have a tremendous positive impact on the already polluted environment.

Third, since everyone has access to water personal financial status will not be adversely affected and in fact will improve thus improving the global economy.

Fourth, because the motor is simple and may be constructed of materials easily available further destruction of the environment will be lessened and no great educational program concerning its construction, operation and maintenance need be implemented.

Fifth, the activating force, cavitation, does not require heat to initiate hence the biosphere will not be heated up from its operation thus alleviating the so-called "Greenhouse Effect".

Sixth, the construction is simple and may be done with off-the-shelf technology.

Seventh, because personal financial situations will tend to improve so too will the financial status of banks, commercial enterprises and respective governments.

Eighth, its fuel being water, uses of coal, oil, gas and nuclear materials as fuels will be dramatically curtailed thus again improving economics as well as reducing further pollution from the use of these obsolete, non-renewable, expensive and polluting fuels.

Ninth, although it may appear that many people now employed in the production and supply of established chemical fuel industries may be thrown out of work which is true; they will be absorbed into other areas of a more positively progressive nature. This shift of employment focus will be much like the one that took place when computers were seen as a similar threat 30 years ago.

Tenth, practical employment of cavitation as an energy source will spark a tremendous surge of research and development into its nature and further use in other applications. Thus, new industries and employment will be created.

The Keely Motor
Potential Uses

The first designs and constructions will be for single speed motors. Applications for this type of rotary motive power unit will include but not be limited to the following:

Autonomous generating systems
- Urban utility plants
- Farm generating systems
- Military generating systems

Pumps
- Agriculture
  - Water
  - Drainage
  - Irrigation
  - Graineries
- Utility plants
  - Water supply
  - Sewage disposal
- Chemical plants
  - Product transfer

Autonomous Rotary Units
- Agriculture
  - General farm use
  - Refrigeration Plants
- Military
- Industry
  - Landscaping
  - Timber
  - Desalination
  - Refrigeration Plants
  - Building/Construction

Patent Application

of

John Ernst Worrell Keely

Specification describing a new and useful
Hydro Vacuo Engine, invented by John W. Keely of the City and County of Philadelphia
and state of Pennsylvania."

Filed November 14, 1872

The end and design of the invention is an engine wherein the actuating power is produced by a vacuum in connection with water pressure.

Figure 1: is a side elevation.
Figure 2: is an end elevation.
Figure 3: is a plan view.
Figure 4: is a sectional side elevation.
Figure 5: is a section through the dotted line 1-1. fig. 4.
Figure 6: is a section through the dotted line 2-2, fig. 4.
Figure 7: is a section through the dotted line 3-3, fig. 4.
Figure 8: is a section of the valve chest.
Figure 9: is the valve or plug.

A. Figures 1, 2, 3, 4, is the bed of the engine B. figures 1, 4, is a cylindrical semi-globular vessel which is bolted to it and near its end. C is a vacuum chamber [?] chamber B. it communicates with it by means of a circle of openings, a, arranged in its base.

Within the chamber B and of very near by the same conformation as the chamber D. its waist or cylindrical part, E, fits snugly and tightly the waist or cylindrical part of the vessel B. there is a space b. between the semi-globular parts of the two vessels.

F is an inverted conical pulsating chamber placed centrally in the vacuum chamber C. its bottom opens into the vessel D. its top is closed by a pulsating diaphragm G. the stem H of which passes through a guide or box C. of the air chamber, I, which is formed from the vacuum chamber C. by the said pulsating diaphragm.

J is a water and air vessel which is suspended in an opening in the bed A of the engine, it is divided into two parts by the pulsating diaphragm K the upper part G is for water, and the lower part, d, for air, a pipe I communicates with the chamber F.

M is the valve chest and N, the cylinder of the engine, on the chamber J the valve O is of the three way plug order and is operated by means of gear wheel and toothed sector e-f figure 1. which are actuated by the eccentric rod and eccentric P, G.

R. is a crank shaft which turns in suitable bearings in the housings R. it connects with the piston and piston rod g. by means of the connecting rod h and the cross head i sliding on the guide rods j. on the inner end of the shaft R. is the eccentric Q. which actuates the gear and sector e-f. by means of the ball and socket eccentric rod P.

SS are shafts which are parallel and turn coincidentally and at the same speed with the shaft R. by means of the spur and pinion gearing T',T',T2,T3 they turn in bearings of the housings R2,

R3 the former carries the ball or fly wheel v while the latter has the crank wheel V on its other end.

W is a balance or compensating lever which turns on the fulcrum K. depending from the bed plate A of the engine, the ball and socket rod W1 connects one end of it to the crank wheel v while W3 connects its other end to the lever W2 which turns on a fulcrum b of the air chamber I.

To start the engine reference being had to figures 1, 4, the piston g. being on its up stroke, the cock m. of the supply pipe X is opened and sufficient water is admitted to fill the waist B of the vessel D the pipe X1 and the chamber J. above the pulsating diaphragm K. to the dotted line 4-4. the air displaced by the water is forced into the pulsating cone F and compressed in the upper part of the chamber J above the said line 4-4. an air pump is now applied to the nozzle Y of the vacuum chamber C. and the air exhausted therefrom, the chamber C. communicating with the semi-globular part of the vessel B through the circle of openings, a, in its base, and with the horizontal pipe X2 which leads from the valve chest M to the vessel B, the air is exhausted from all at the same time.

If the inlet cock, M. of the supply pipe X be opened to its extent and a full water pressure be admitted to the waist E of the vessel D it will rise in the semi-globular part of the same and also run through the pipe X1 into the upper part of the chamber J until the compression of the air in the conical pulsating chamber F and in the part, d, of the chamber J equals the pressure of the water, the cock m. of the pipe T being open to permit a free circulation of air between the chambers, the pulsating diaphragms G and K. will be extended, the stem H partaking of the outwardly motion of its diaphragm will be raised vertically and thereby lift the lever W3 it will be readily seen that there is an uninterrupted water or other fluid flow between the vessel D and the upper part of the chamber J. and an uninterrupted air flow between the lower part of the same and the conical pulsating chamber F which opens into the upper part of the said vessel D.

A weight sufficient for obtaining the requisite pressure being hung so the lever W3 its force on the stem H causes the pulsating diaphragm G to compress the air in both chambers F, J. downwardly upon the water of the vessel D. and upwardly by the diaphragm K. against the water on the pat[?] c1 of the chamber J.

The descending vibration of the lever W3 through its end or connecting rod W2 depressed the end, O, of the compensating lever W. and of consequence raises its opposite end p, the connecting rod W1 of that end turns the crank wheel V. since the shafts SSR turn coincidently and at the same speed through the medium of the spur gear and pinion T3 T2 T T. the eccentric Q. and rod P working the spur gear and sector e-f. slowly turn the plug valve O. until its port q and the valve chest port v leading from the chamber J form a continuous port to the cylinder N.

The water in the pipe X1 in the vessel D and in the upper part of the chamber J and also the compressed air above the line 4-4 acting under the influence of the compressed air in the conical chamber F and in the lower part of the chamber J. rushes through the port, v, and pressing against the under side of the piston g, causes it to ascend; when it arrives at the end of its stroke, the eccentric Q and the rod P. together with the gear and sector e-f will have turned the plug valve V, so as to shut off all communications of this cylinder N with chamber J. and opened its port into the pipe X2 through the port X[?].

The vessel B, the chamber C and the pipe X2 from one continuous vacuum, the instant the ports between the cylinder N and the pipe X2 are opened, the air and water contained in the cylinder is sucked into the vacuum, the pressure of the atmosphere acting on the piston through the openings, S, in the cylinder head makes the return or down stroke, the back pressure of the air and water being renewed by the vacuum.

The set of the crank wheel v should be such that as the piston ascends the end p of the compensating lever W should descend and the end, o ascends, whereby the lever W is raised gradually and the pulsating diaphragm G is permitted to expand or left unloaded by the expansion of the air in the chambers F, J and the pressure of the water flowing through the supply pipe X.

A few revolutions of the engine will effectually exhaust all the air from the upper part of the chamber J, the valve and valve chest ports, and from the cylinder beneath the piston.

To draw off the water as exhausted from the cylinder after performing its work as a mechanical agent, an exhaust pipe X3 taps the semi-globular part of the vessel B near its top as shown at figures 1, 2, 3, 4, 7, its other end dips into water to prevent the entrance of air, it is freed of its air at the same time with the vacuum chamber C. and the vessel B.

The pipe X3 prevents the water from raising in the chamber or vessel C higher than the bottom of the vacuum chamber C. it should maintain the same level in the vessel D. if it should rise into the pulsating chamber E. as shown at figure 4. it would reduce the volume of air and thereby materially interfere with the capacity of the engine.

When it is desired to stop the engine an air cock L on the swell or enlargement of the pipe X2 is opened which admits air to the chamber C. and destroys its vacuum.

I claim as my invention:

First: The cylindrical semi-globular chamber B. in combination with the vacuum chamber C. and the pipes X2, X3 for the purpose shown and described.

Second: The cylindrical semi-globular chamber or vessel D in combination with the conical chamber E. the pulsating diaphragm G. the stem H the lever W3, and the supply pipe X for the purposes shown and described.

Third: The cylindrical semi-globular vessel D in combination with the pulsating chamber E the pipe X1 the pulsating chamber J. and the pipe I. for the purpose shown and described.

Fourth: The chamber J. in combination with the pulsating diaphragm K. for the purpose shown and described.

Fifth: The pulsating chamber J. in combination with the valve chest M. and the cylinder N for the purpose shown and described.
Sixth: The valve chest M. in combination with the pipe X2, the vessel B. and the vacuum chamber C. for the purpose shown and described.

Seventh: The valve chest M. in combination with the valve plug O. the spur gear, e. the sector f. eccentric rod P. the eccentric G. for the purpose shown and described.

Eight: The shaft R. in combination with the eccentric Q. the eccentric rod P. the toothed sector f. the spur gear e. and the valve O. for the purpose shown and described.

Ninth: The horizontal shafts R. SS. the spur gear and pinions, T.T. T2 T3 and the balance or ball wheel U for the purpose shown and described.

Tenth: The crank wheel V in combination with the rod W1 the compensating lever W2 for the

purpose shown and described.

Eleventh: The air cock Z in combination with the pipe X2 for the purpose shown and described.

In testimony whereof I hereonto sign my name in presence of two subscribing witnesses.

John W. Keely

John W. Keely, the above name petitioner being duly sworn deposes and says that he verily believes himself to be the original and first inventor of the new and useful Hydro Vacuo Engine described and claimed in the foregoing specification that he does not know and does not believe that the same was ever before known or used, and that he is a citizen of the United States.

Fig. 2.

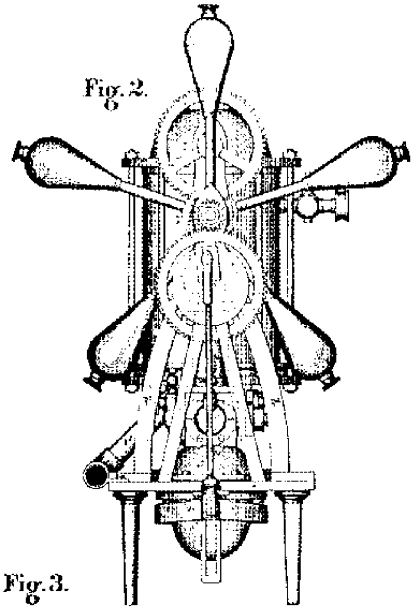
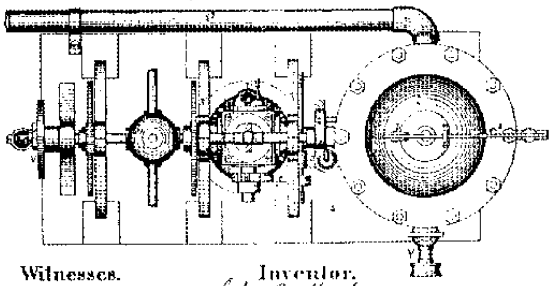


Fig. 3.



Witnesses.

Inventor.

Fig. 5.

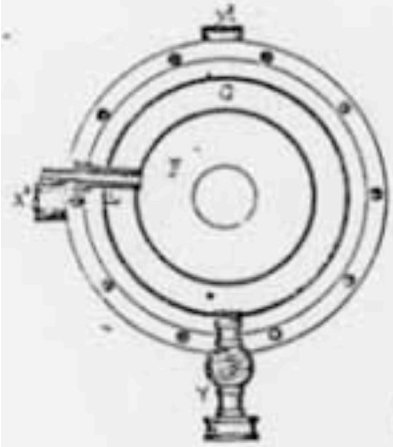


Fig. 6.

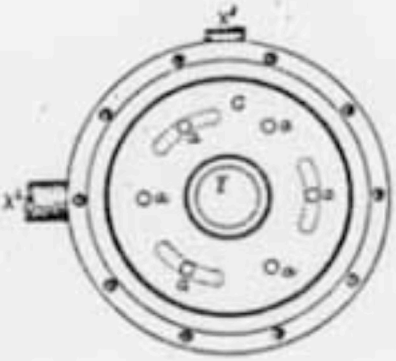


Fig. 7.

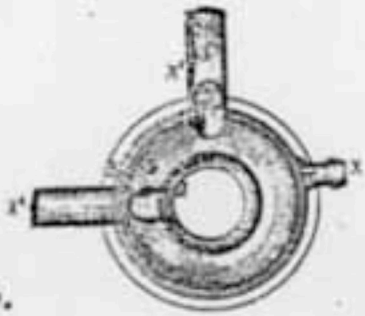


Fig. 8.

Fig. 9.

Witnesses.

Jo. Saunders Bell.

J. A. Schuckers

Inventor.

John W. Keely

by Francis D. Pastorius

his Atty in fact

The Keely Motor
Prior Engineering and Substantiation of Principle

"The collapse of the smaller vapor filled cavities causes many extreme results as the intensity of the resulting shock wave may be considerably greater than the originating action. As an analogy with an explosion, the initiation of the cavities is the trigger action while their collapse is the explosion." (1)

"It has been shown that rectification of the gas diffusion occurs because the surface area of the bubble varies during the sound pressure cycle. During the positive half-cycle the solution is undersaturated and gas diffuses out of the bubble; during the negative half-cycle it is supersaturated and gas flows in. But the surface area is larger during the negative half than during the positive half-cycle, so that there is an excess influx. If the rate of sonically induced diffusion into the bubble exceeds the rate which the gas diffuses because of the excess pressure resulting from the surface tension, the bubble grows in size." (2)

"Cavitation in a tube can be explained according to Bernoulli's equation:

$$\text{hydrodynamic pressure} + \frac{\text{density} \bullet \text{velocity}^2}{2} = \text{constant}$$

It is found that the sum of pressure and kinetic energy in a flowing liquid is constant. Thus the velocity of a liquid passing through a restriction may become so high that the hydrodynamical pressure is reducted to the vapor tension." (3)

"Lord Raleigh in 1917, calculated the pressure developed during the collapse of a spherical cavity. His equation was

$$\frac{P'^2}{2\beta} = \frac{P}{3}\left(\frac{R_0^3}{R^3} - I\right)$$

where

P	pressure at infinity external atmospheric pressure
R_0	initial radius of the cavity
β	the coefficient of compressiblity
P' and R	correlated pressure and radius of the cavity during the collapse

Calculation of the above equation shows that pressure of thousands of atmospheres may be developed at the moment when the cavity collapses to a small fraction of the original diameter. Such collapses are, therefore, bound to cause enormous mechanical effects, as high kinetic energies are being concentrated at very small spots." (4)

(1) Crawford, Alan E.,*Ultrasonic Engineering with particular reference to high power applications*; Butterworths Scientific Publications, 1955, London. page 26.
(2) Crawford, Alan E.,*Ultrasonic Engineering with particular reference to high power applications*; Butterworths Scientific Publications, 1955, London. page 30.
(3) Prakash, Satya and Ghosh, Ashim Kumar; *Ultrasonics and Colloids*; Scientific Research Committee, Allahabad, India, 1961. page 114
(4) Prakash, Satya and Ghosh, Ashim Kumar; *Ultrasonics and Colloids*; Scientific Research Committee, Allahabad, India, 1961. page 115

Water Hammer
Definitions and Elementary Theory

Water hammer is the rise in pressure that occurs when the water flow in a pipe line or closed conduit is reduced or stopped, regardless of how this flow is checked. Hammer can occur in any line carrying liquids. Usually, the problem is important only in water lines.

The classical water-hammer problem is that of protecting penstocks that supply water to water turbines. If the flow in the penstock is suddenly reduced by action of the gates controlling the water flow to the turbines, the penstock pressure at the gate immediately rises, the drops below the initial pressure, and continues to surge in regular periods until friction damps the surge out.

Pump-discharge-lines pressures will surge in the same way if all the operating pumps are stopped at once, except that the initial surge which occurs at the pumping end of the line is downward. The rise in pressure following the downward surge may be sufficient to rupture the pipe or pull the line apart unless protection is provided.

The formulas most useful in water-hammer problems are (ASME, ASCE symbols)

$$a = 4{,}720/\sqrt{1 + (Kd/Ee)}$$

$$h_{max} = aV_0/g$$

Period of pipe line = $2L/a$ = one interval, seconds

where a = the velocity of the pressure wave in the pipe line, fps. (This is the velocity of sound in the water of the the pipe line.)

K = the bulk modulus of the liquid in the pipe line, psi (approx. 300,000 for water)
E = Young's modulus for the pipe-line material psi (30 million for steel)
d = the diameter of the pipe
e = the wall thickness of the pipe; d and e are always in the same units, *i.e.*, both feet or both inches.
h_{max} = the maximum pressure rise (or drop) that can occur if the water flow is stopped instantly and there are no complicating features such as nonuniform pipe, branch lines, *etc*. The unit h_{max} of the formula is in fact of the liquid flowing.
V_0 = The velocity in the pipe line just previous to the disturbance causing water hammer, fps
g = gravity, ft/sec2
L = the length of the pipe line, ft

Other terms used in the argument are

h = the hammer pressure actually developed, ft
H_0 = The operating or steady-state pressure in the pipe line just previous to the disturbance causing water hammer, ft
T = the actual time in which flow is stopped, sec

The value of a normally is somewhere between 3,000 and 3,500 fps. An accurate value usually is not needed for estimating surges in pump discharge lines.

The maximum water-hammer pressure which can occur in a simple pipe system is h_{max} , but this is not the maximum pressure in the pipe line because h_{max} adds to H_0 the existing pressure in the line just previous to the disturbance. The maximum pressure existing is, then h_{max} plus H_0, and if H_0 is near the design pressure, it may be noted that rupturing pressures may occur. The water-hammer pressure h_{max} is alternately both positive and negative. When negative, the minimal pressure is H_0- h_{max}. Obviously, the pipe-line pressure cannot reduce below zero absolute. If the downward surge carries to zero, vacuum will form, and the collapse of this vacuum may cause a major water-hammer blow. It may be noted that h_{max} is independent of the length of the line and depends only on the water and the wave velocities. The value of h_{max} is usually between 40 and 45 psi per fps of water velocity destroyed.

The period of the pipe line, $2L/a$ is, by inspection, merely twice the length of the line divided by the wave velocity. It is the time it takes the pressure wave front to travel from the point of origin to the end of the line or other reflection point back to the origin. The wave of rarefaction, or subnormal pressure wave, also takes $2L/a$ sec to make the round trip. The time by stop watch between two crests of the pressure wave is then $4L/a$ sec. The value of $2L/a$ is important because the actual hammer h is reduced below h_{max} if the time it takes the flow to stop is greater than $2L/a$. This is true because the subnormal phase of the wave reaches the point of origin before the pressure wave has ceased to build up and adds geometrically to the pressure wave. The value of h is for ordinary lines about equal to

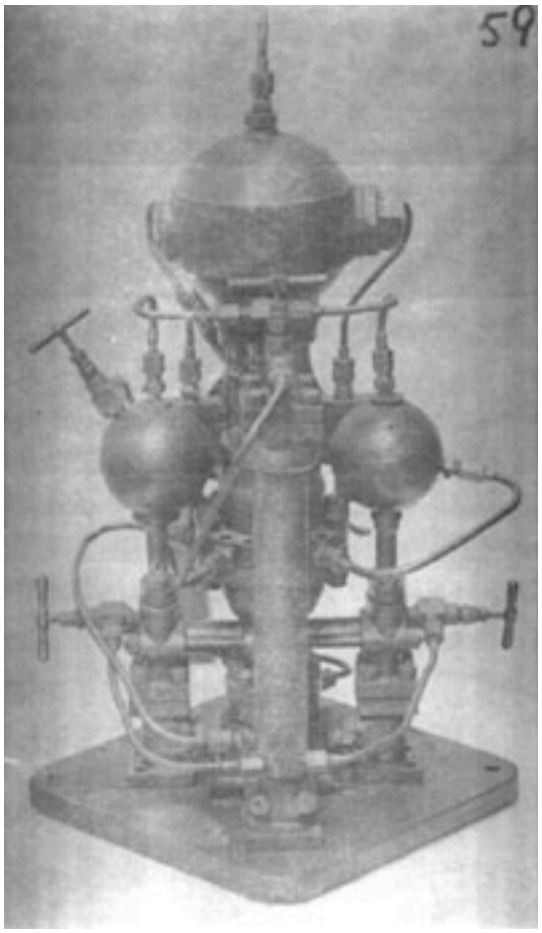
$$h_{max}/T/2L/a = h_{max}2L/aT$$

with the understanding that in this formula T cannot be less than $2L/a$. This formula holds reasonably well except for lines of high velocities and low pressures, in which case h is much increased. In general, T should be five to ten times the value of $2L/a$ to eliminate destructive water hammer.

On power failure, the pressure drop at the pumps is never h_{max} except for very long lines of high H_0. Short lines, except those of high water velocities, have very little pressure drop since T is large compared to $2L/a$. Such lines usually need no hammer protection. For intermediate lines the pressure drop on power failure is about one-half aV_0/g. The subsequent pressure rise may be slightly more than that unless a vacuum has formed, in which case nearly the full water hammer develops. [1]

(1) Segel, Joseph; *Water Hammer Protection for Pump Discharge Lines*, Plant Engineering Handbook; McGraw-Hill, 1950.

$$\text{velocity of pressure wave in pipe} = 4{,}720 \sqrt{1 + \left(\frac{(\text{bulk modulus} \bullet \text{diameter})}{(\text{Young's modulus} \bullet \text{wall thickness})} \right)}$$



Water Hammer

Water hammer is the series of shocks, sounding like hammer blows, produced by suddenly checking the flow of water in a pipe. If a valve, turbine gate, or faucet is suddenly closed, kinetic energy of the arrested column of water is expended, if no relief devices are provided, in compressing the water and in stretching the pipe walls. Starting at the suddenly closed valve, a wave of increased pressure is transmitted back through the pipe with constant velocity and intensity. The shock pressure is not concentrated at the valve, but if a bursting pressure is produced, it may show its effects near the valve simply because it acts there first. The velocity of the pressure wave for ordinary cast-iron pipe, 2 to 6 in. in diameter, is about 4,200 fps; for a 24 in. pipe it is about 3,300 fps; it depends on the elasticity of the metal and upon the ratio of its thickness to the diameter of the pipe. If the pipe were perfectly rigid, the velocity would be that of sound through water, about 4,700 fps.

The increase of pressure is proportional to the arrested velocity of flow and to the speed of propagation of the pressure wave. This increase is about 60 psi for each foot per second of extinguished velocity for 2 to 6 in. pipes, and about 45 psi for each foot per second for 24 in. cast-iron pipe. These increases of pressure will be attained only in case the valve is closed in less time than one round trip of the pressure wave.

When the pressure wave has traveled upstream to the end of the pipe where there is a reservoir or a larger main (the whole pipe then being under increased pressure with checked flow throughout), the elasticity of the compressed water and that of the distended pipe reverse the flow at that end of the pipe, and a wave of normal pressure (that of the reservoir or main) travels downstream, the flow being progressively reversed as the compressed water expands. When this wave of normal pressure reaches the valve, the kinetic energy of the column of water with reversed flow tends to create a vacuum at the valve. There the reversed flow is checked and the checking proceeds progressively upstream accompanied by a wave of subnormal pressure. When this wave reaches the upstream end (the whole pipe then being under subnormal pressure), the greater normal pressure in the reservoir or large main starts to flow into the pipe, and a wave of normal pressure and forward flow travels downstream. When this wave reaches the valve, there is forward flow throughout the pipe, the conditions being the same as when the valve was suddenly closed, and a wave of increased pressure and of checked flow again starts upstream. A complete cycle of pressure waves and reversals of flow occupies the time required for two round trips. The amplitude of the pressure vibrations becomes less with succeeding cycles because of friction, but the time interval remains constant.

If a high-pressure wave, in its travel through the pipe, enters a branch pipe with a closed, or "dead," end, there may be a considerable increase of pressure when the wave strikes the closed end.

As the intensity of the excess pressure in the "hammer" wave depends on the amount of "extinguished" velocity, the same excess pressure is produced by suddenly reducing the velocity from 7 to 4 fps as by entirely stopping a velocity of 3 fps. If the flow is not checked rapidly, so that the wave from the first movement of the gate has time to travel upstream to the end and back again several times while the checking is in progress, the excess pressure is very much reduced. Hence, the wisdom of using slow-closing valves on long pipe lines.

The excess pressure and the speed of the pressure waves are given by the formulas:

$$p = V\sqrt{Ew/g} \qquad S = \sqrt{Eg/w}$$

and also:

$$S = \sqrt{(g/w)(EE't)/(tE' + DE)} \qquad p = V\sqrt{(w/g)(EE't)/(tE' + DE)}$$

[1][2] In these formulas

- p is the excess pressure intensity
- S the speed of transmission of the pressure wave through the water in the pipe. The first two simpler formulas consider the pipe as perfectly inelastic. The last two formulas take into account the elasticity of the metal of the pipe.
- V is the extinguished velocity, fps
- w the weight of 1 cu ft of water
- g = 32.2
- E the bulk modulus of the elasticity of water = about 300,000 psi
- E' the liner modulus of the pipe metal = 30,000,000 psi for steel
- t the thickness of the pipe metal
- D internal diameter of the pipe.

The same system of units should be used throughout. If the fps system is used, the above values for E and E' must be multiplied by 144. [3]

(1) Church, *Hydraulic Motors*, Wiley, and Proc. Am. Water Works Assn., 1904
(2) *Symposium on Water Hammer*, 1933, jont ASME and ASCE.
(3) Marks, Lionel S.; *Mechanical Engineers' Handbook*, McGraw-Hill Book COmpany, Inc., New York, 1951.

CAVITATION AS A POWER SOURCE

What Others Say

"The collapse of the smaller vapor filled cavities [during cavitation] causes many extreme results as the *intensity of the resulting shock wave may be considerably greater than the originating action.*" [(1)]

"Cavitation is mainly known for its harmful effects, namely, loss of performance, erosion, and noise.[(2)] However, attempts to induce and harness cavitation for useful purposes have been increasingly successful. [For instance] In high-pressure jets, cavitation has for some time now been purposely induced in order to increase their drilling, cutting, and cleaning capabilities."[(3)]

"... *pressure of thousands of atmospheres* may be developed at the moment when the cavity collapses to a small fraction of the original diameter. Such collapses are, therefore, bound to cause *enormous effects, as high kinetic energies* are being concentrated at very small spots."[(4)]

"To give an idea of the amazing effects of cavitation, it may be pointed out that after a destroyer had rushed for several hours at maximum speed, the armor plates above the propeller were pierced by a hole of the dimension of about one square foot."[(5)]

"If the cavities are larger than about --- in diameter the pressure at the solid [boundary] is about 1000 atmospheres (14,000 psi)."[(6)]

"While denucleated liquids may have a number of practical applications such as their use for a transmission medium in high intensity ultrasonic equipment, the use of enhanced nucleation in liquids could have far reaching possibilities. If it were possible materially to reduce the power necessary for active cavitation many of the actions utilizing the phenomenon of cavitation would become more economic and practical from the point of view of commercial exploitation."[(6)]

(1) Crawford, Alan E.,*Ultrasonic Engineering with particular reference to high power applications*; Butterworths Scientific Publications, 1955, London. page 26.
(2) Hammitt, F. G., "Cavitation and Multipahse Flow Phenomena", McGraw-Hill International Company, 1980.
(3) Johnson, V. E., Jr., Chahine, G. L., Lindemuth, W. T., Conn, A. F., Frederick, G. S., and Giacchino, G. J. Jr., "Cavitating and Structured Jets for Mechanical Bits to Increase Drilling Rates." ASME Journal of Energy Resources Technology, Vol. 106, 1984, pp. 282-294.
(4) Prakash, Satya, and Ghosh, Ashim K., "Ultrasonics and Colloids", Scientific Research Committee, Allahabad, India, 1961.
(5) Prakash, Satya, and Ghosh, Ashim K., "Ultrasonics and Colloids", Scientific Research Committee, Allahabad, India, 1961.
(6) Crawford, Alan E.,*Ultrasonic Engineering with particular reference to high power applications*; Butterworths Scientific Publications, 1955, London.

THE KEELY MOTOR BUBBLE
MacVICAR'S LOGICAL ANALYSIS

(from *Keely and His Discoveries*)

For it is well known that bodies act upon one another by the attraction of gravity, magnetism, and electricity; and these instances show the tenor and course of Nature and make it not improbable that there may be more attractive powers than these. For Nature is very consonant and comfortable to herself. - Sir Isaac Newton.

The Scotch author, MacVicar, from whose "Sketch of a Philosophy" has been compiled "Ether the True Protoplasm," published this year in the *New York Home Journal*, says in his "Enquiry into Human Nature," written in 1852, "Modern science is certainly on the way to the discovery that, so far as is cognizable by us, throughout the whole universe the same laws are at work and regulate all things. The *mecanique celeste* of mind is still waiting its Newton to disclose them to us."

Looking upon the discoverer of etheric force as the Newton, whose coming was forecast by MacVicar, it is satisfactory to see that Keely, in his field of research, eventually adopted the methods which his forerunner advocated nearly forty years ago; but not until after many years of blind grappling with the mechanical difficulties which he encountered, in his efforts to control the unknown Genii, which he himself declares that he stumbled upon in quite another field of research. Keely was experimenting in 1875 on what he called a hydro-pneumatic-pulsating-vacuo engine, when, "accidentally," the first evolution of disintegration was made. The focalization of this quadruple force, acting on one general centre of concentration produced partial molecular subdivision, resulting in a pressure of some three thousand pounds per square inch. Mr. Keely was himself amazed at this evidence of the energy which he had evoked, and at once turned his attention to researching its nature, with the result that he came to the conclusion that he had partially resolved the gaseous element of water by crude molecular dissociation. This was his first step, and the necessary introductory one, towards the elimination of ether; but at that time, to use his own words, he had not the remotest idea of the etheric element proper. Since then he has constructed innumerable machines to subdivide or dissociate the molecular; but it was not until he had instituted certain acoustic vibratory conditions that he began to realize the magnitude of the element that he is now controlling with his vibratory disintegrator. Yet, even this instrument was only the stepping-stone towards polar-sympathetic-negative-attraction.

In 1878 Mr. Keely conceived and constructed an instrument which he called a "vibratory lift," and, while experimenting on the improvised multiplication by this medium, he had occasion to put a piece of marble, weighing twenty-six pounds, on a steel bar to hold it in place, when then and there his first discovery of the disintegration of mineral substance took place. From that time progressive research of the most arduous nature has brought him to his present standard in vibratory physics. In the winter of 1881-82, when threatened with imprisonment by the managers of the Keely Motor Company for not disclosing his secret to them, which then would have been like pricking a bubble, he destroyed his vibratory lift and other instruments that he had been years in perfecting. At this time so hopeless was Keely, that his plans were made to destroy himself, after destroying his devices. At this critical juncture he received unexpected aid. Again, in 1888, before he was taken to a felon's cell in Moyamensing Prison by decree of Judge Finletter for alleged contempt of court, he broke up his vibratory microscope, his sympathetic transmitter, and some devices, which have taken much of his time since to reconstruct. It would seem to be incomprehensible that a man who believes he has been specially endowed by Providence to convey great truths to the world, should have destroyed instruments which were the result of the labour

of many years of research; but Schopenhauer tells us that genius possesses an abnormally developed nervous and cerebral system that brings with it hyper-sensibility, which in union with intensity of will-energy, that is also characteristic of genius, occasions quick changes of mood and extravagant outbursts. Schopenhauer also explains why it is that men of genius are ignored by the age in which they appear:- "The genius comes into his age like a comet into the paths of the planets, to whose well-regulated and comprehensible order its entirely eccentric course is foreign. Accordingly he cannot go hand in hand with the existing regular progress to the culture of the age, but flings his works far out on the way in front (as the dieing Emperor flung his spear among the enemy), which time has first to overtake. The achievement of the man of genius transcends not only the power of achievement of others, but also their power of apprehension; therefore they do not become directly conscious of him. The man of talent is like the marksman who hits a mark the others cannot hit; the man of genius is like the marksman who hits a mark that the sight of others cannot even reach." In one sense this truth applies to all men, for, says Cicero, no man is understood excepting by his equals or his superiors.

Admitting all that has been said of the difficulties attendant upon the comprehension of a genius by the age in which he lives, it does not require genius to understand the blunders which, perpetrated by the managers of the prematurely organized Keely Motor Company, have placed Mr. Keely, as well as themselves, in false positions with the public; leaving him since the winter of 1880-81 to bear the whole burden of the infamy brought about by their having offered stock for investment which could possess no tangible existence in the shape of property until the laws governing the unknown force that he was handling had been studied out and applied to mechanics in a patentable machine. To those informed that this company ceased to hold annual meetings as far back as 1881 it will be a matter of surprise to hear that, sitting up in its coffin, seven or eight years after its burial, it called another annual meeting, and that now its managers are again applying the thumb-screw, as in past years; pressing their claims and threatening a suit for obtaining money under false pretences, unless Mr. Keely renounces his plan of progressive research, and gives his time to the construction of engines for the Keely Motor Company. This requirement, as was said in 1881, of a similar effort, is as sensible, under existing conditions, as it would be to require Keely to devote his time to growing figs on thorn trees. It is from the "Minority Report to the Stockholders of the Keely Motor Company from the Board of Directors" (made by a member of that board in 1881, John H. Lorimer), that the material is gleaned for disclosing facts which it is due to Mr. Keely should now, since this last attempt to intimidate him, be given to the public. The stock of that company is not lessened in value by the mismanagement of its officers and directors; for Mr. Keely's moral obligations to its stockholders are as sacred to him as if the company had not long since forfeited its charter. When Mr. Keely became financially independent of the company last March, speculation in the stock of that company received its death blow, and the "Keely Motor Bubble" burst, leaving to the stockholders all that ever had any tangible existence in the shape of property in a more valuable position than it had ever been before. Mr. Lorimer is a gentleman of Scotch birth, who was elected a director of the Keely Motor Company in 1881, and who resigned in 1882, because he was "unable to carry the enterprise," and unwilling to fall in with the policy of the old directors. Before resigning, he set himself to studying the position of affairs with a view to forming for the Board a definite plan of action which ordinary business principles would justify.

This course resulted in a thoroughly business-like letter to Mr. Keely in which, under nine heads, Mr. Lorimer set down the conclusion he had reached as to the cause of the difficulties that had culminated in a threatened law suit, and Mr. Keely was ordered to ask that a special meeting of the Board should be called at once, to consider any proposition he should see fit to make towards settling the question whether he should proceed with the company's work or be permitted to defer it, as he so much desired, until he had fully developed the adaptation of his power already known to him or hereafter possible of discovery by him. Mr. Lorimer added:- "And now, in conclusion, I may say to you that the above deductions from the history of your motor are the

result of patient and laborious inquiry on my part, and I am truly at a loss to understand how, or in what manner, other than that herein suggested, you can honourably vindicate your position; and as no one I have met connected with the enterprise, or personally acquainted with you, hesitates for an instant in crediting you with the most unswerving integrity, I have no hesitation in offering the above suggestions for your consideration; and I trust you will so far adopt them as to enable the active portion of your friends to bring the organization rapidly into harmonious accord with you in the development of what all seem to think is the greatest wonder of our civilization, the early completion of which will lift you to the highest pinnacle of fame as a scientist, and make them co-dispensers with you of the God-given wealth of which you hold the key." The date is 10th of February, 1881.

This letter was followed by another dated February 11th, in which Mr. Lorimer submitted certain conclusions, arrived at after meeting in New York with several members of the Board of Directors, one of which reads:- "It seems to be generally understood that without your hearty cooperation and good will, the company cannot realize value upon any existing contacts, or any may hereafter make with you."

At this time Mr. Lorimer states that he had the opportunity presented of studying, semi-officially, the very peculiar man whose genius held his friends so spell-bound that they lost their power (if such they possessed) to adapt business methods to the enterprise. To meet him socially in his shop, Mr. Lorimer writes, "after his day's work, was I think, invariably to be impressed with his earnestness, honesty of purpose, and above all, with confidence in his knowledge of the plane of science he was working in (acoustics), and, at the same time to be impressed with the folly of basing calculations for the government of the business details of the organization upon the statements made by him while contemplating the possible results of his researches."

With the hopeful spirit of an inventor, Mr. Keely always anticipated almost immediate mechanical success, up to the hour in which he abandoned the automatic arrangement that was necessary to make his generator patentable. From that time his line of perspective extended, and he began to realize that he had been too sanguine in the past. He had been like a man grappling in the dark with a foe, the form of which had not even presented itself to his imagination; but when, in 1884, MacVicar's work on the structure of ether came like a torch to reveal the face of his antagonist, what wonder that he, with the enthusiasm of Paracelsus, felt his

. . . "fluttering pulse give evidence that God
Means good to me, will make my cause His own;"

and, as in 1881, again rashly bound himself anew, by fresh promises, made to those who had the power to give or to withhold the sinews needed in the warfare he was waging?

To return to the report. During the negotiations which followed, facts in the history of the company were developed which convinced Mr. Lorimer that Mr. Keely was totally unable to measure time, or define his plans, because of the ever-changing results attained by him, in researching the laws governing the force he was trying to harness. At this time the treasurer of the company was proposing to bring over from New York to Philadelphia a number of capitalists to witness an exhibition of the production of the force, in order to dispose of 500 shares at $25.00 dollars a share. To this plan Mr. Lorimer objected, writing to the treasurer, "I fear that you would be putting yourself in a false position with the friends you might induce to take stock at the figures named," and Mr. Keely himself at first refused to give the exhibition, but upon the application of the thumb-screw, kept in readiness, it took place. At this time Mr. Lorimer wrote to the president of the company, "If Keely gives us the benefit of his discovery, it will require all our energies to guide our enterprise; and, on the other hand, if he dies or is forestalled, it will need all our care and attention to take care of our reputations. . . . The fact that the Board has some deli-

cate and important work to perform, brings us to the question, Are we properly organized to perform our part? If we are, let us show it by our acts, and, if not, let us act like men, worthy the important trust before us. If I am overestimating the character and importance of this work, you can show it to me; and *per contra*, if I am correct, you can and will accept the responsibilities of the position you hold, no matter how unpleasant, no matter how irksome, if understood by you and honourably supported by us."

Mr. Lorimer then prepared this summary, or analysis of the situation.

SUMMARY.

26th July, 1881.

First.- The existence of a discovery or invention which from evidences of its adaptability (when complete) to the industrial arts and sciences, may be esteemed the most valuable discovery of civilization in modern or in ancient times, inasmuch as it revolutionizes all known methods of generating power.

Second.- The retention by the discoverer and inventor of all the secrets whereby these discoveries can be utilized by the public, thus making their future existence, so far as the Keely Motor Company is concerned, depend entirely upon his life and goodwill.

Third.- The existence of a corporated company, organized for the purpose of furnishing funds for the development and completion of the discovery, and for the final control of certain specified inventions, in certain specified localities.

Fourth.- The contracts under which the above-mentioned control of certain inventions is vested in the Keely Motor Company, being mere evidences of intention, have no real the contracts by transfer of the same to the company.

Fifth.- If any conflict should arise between the company and the inventor, in which the latter *felt justified* in withholding the transfer, the existing contracts might be a good foundation to build litigation upon but not good for investment in.

Sixth.- The uncertainly of the future of the enterprise, as thus indicated, must of necessity invite speculative management; and while speculation under some circumstances is legitimate and laudable, under other conditions it may become illegitimate and reprehensible.

Seventh.- The existence of a speculative management in Keely Motor affairs has, of necessity, developed two interests - one which holds that the completion of the discovery in all its possible grandeur should ever be the sole object of its management, and the other, believing that on account of the human uncertainty of the completion of the invention, they are in duty bound to make quick recoveries on their investments, so that they may be safe financially, in the event of a failure by Keely to perfect his inventions."

It is not necessary to pursue this summary farther, as the manner in which Mr. Lorimer has set down the facts already given, makes clear the nature of the conflicting interest that brought about the antagonism which he attempted to subdue, bringing such a spirit of fairness and justice into his efforts as must have crowned them with success, supported as he was by Mr. Keely, had it not been that *those who advocated following a policy which, at best, aimed no farther than at the recouping of losses to themselves, were in the majority*. It was at this time that Mr. Keely manifested his willingness to assume, on the one hand, all the responsibility of the proper development of his discovery; or, on the other hand, all the disgrace accompanying failure by his offer to purchase a controlling interest in the stock, fifty-one thousand shares of which, in order to pre-

vent speculation, he agreed to lock up for five years, and to give the company a bond restraining him from negotiating or parting with a single share of it in that time, the stock to be paid for as soon as certain deferred payments had been made to him. This proposition of Mr. Keely to the Board of Directors, October 25th, 1881 (and laid upon the table by a large majority as unworthy of consideration), was made from his earnest desire to control the presentation of his life's work to the world in a just and honorable way; having recognized, with Mr. Lorimer, the utter impossibility of reconciling the numerous interests created by mistakes of himself and the mismanagement of the Board, unless he could thus obtain the power to deliver an unencumbered enterprise to the world. In the opinion of Mr. Lorimer, during the negotiations which he conducted between the management and Mr. Keely, the latter was the only one who had manifested any consistency or strength of purpose, so far as the facts gave evidence, which were brought before him, of the history of the company. When the validity of the contracts made with Mr. Keely while he was president, or director of the company, were disputed, he was called upon to resign, which he did, and yet no steps were taken to ascertain the value of the existing contracts, which had all been made with him while he was both president and director, and which were therefore illegal. Proceedings in equity were commenced against Mr. Keely, by the Committee of the Board of Directors having the matter in charge, late in the year 1881, while Mr. Lorimer's report was still in the hands of the printer. "The spectacle of a Board of thirteen Directors, composed of business men," writes Mr. Lorimer, "claiming that they have been foiled in their business calculations by a man whose mind has been so thoroughly absorbed in researching the problems presented by his wonderful discoveries that he could not possibly compare with any of them in business *tact*, is truly a phenomenon which is not easy of explanation on any hypothesis, but the one that their visions of prospective wealth have been so overpowering as to undo their prudence; and then having in due process of time discovered their error, it certainly is an edifying spectacle to see them now trying to throw all the blame on one poor mortal wholly absorbed in his inventions, and by these efforts disturbing that mental equilibrium of both the inventor and themselves, which is absolutely necessary to ultimate success. When boys, in early summer, pick unripe fruit and eat it, because of their unwillingness to await the ripening thereof, they sometimes suffer acutely for their haste. Yet no one ever thinks of punishing the tree because of their sufferings; nor is it deemed necessary to justice to preserve the fruit of the tree, when ripe, for the sole use of the impatient ones as a recompense for their early sufferings! So it has been with the Keely Motor Company; undue haste to gather the golden fruit that was to come from it, has led to a great deal of suffering financially among a few impatient believers. Still it does not seem to me too wise to curse the inventor, or his inventions because he has not given us the fruit when we expected it would be ripe." . .

The effort to force Keely to divulge his secrets failed, for at that time he had nothing of a practical nature to divulge, and though possessing no business qualifications, he was too shrewd to cut off any of his resources for supplies, necessary to enable him to persevere in his efforts to attain some practical result, as he surely would have done, had he said, "I know very little more than you know of the laws governing the force I have discovered. I can only control their operation by experimental research, and the more time that is wasted in building engines, until I have made myself acquainted with these laws, the longer will you have to wait for your golden fruit." Mr. Keely was no more able at that time to give the faintest of the present stage of his researches than Professor Leidy or Dr. Wilcox could now, after witnessing the experiments in sympathetic attraction, write out a clear formulation of its governing law, and an inductive substantiation of it. Even were it possible, no reader could understand it because the discovery made by Mr. Keely is not in accordance with any of the facts known to science. Mr. Keely's experiments in disintegrating water prove that incalculable amounts of latent force exist in the molecular spaces; but in the opinion of scientists, molecular aggregation is attended with dissipation of energy, not with absorption of energy. If the men of science are right, then there must be an absolute creation of energy, for only by admitting its absorption in aggregation, could molecular dissociation supply the force witnessed. Keely, of course, denies any creation of energy, claiming only that he can produce an indefinite supply by the expenditure of an infinitesimally small amount of energy.

Every new discovery necessitates a new nomenclature. The vocabulary coined by Mr. Keely, to meet his requirements in formulating his hypotheses into theories as he progresses, conveys as little meaning to those who read his writings, as the word "electricity" conveyed 200 years ago. Professor Crookes remarked that reading Mr. Keely's writing was like reading Persian without a dictionary. Another learned professor said that they seemed to him to be composed in an unknown tongue, so profoundly unintelligible had be found the extract sent to him. One must be familiar with Mr. Keely's instruments and their operation, in order to comprehend even the nature of his researches.

An another of philosophical works, who was present at some experiments illustrative of varying chords of mass, and whose theories had not been in unison with those of Mr. Keely on that subject, sat for some time after the demonstration with his eyes fixed upon the floor, wearing as serious an expression of countenance as if he were looking on the grave of his most cherished views. The first remark that he made was, "What would Jules Verne say if he were here?" The rotation of the needle of a compass, the compass placed on a glass slab and connected with the transmitter by a wire, 120 revolutions in a second, had the same effect upon the scientists present, one of awe; so completely were they transfixed and unable to form a conjecture as to the mysterious influence from any known law of science. There was only one professor present, *a very young man*, who ventured the whispered suggestion of concealed mechanism under the pedestal; and as Mr. Keely soon after had occasion to wheel the pedestal across the room, showing that it was not stationary, and could have no concealed connection within or without, the young professor took up another line of conjecture. As MacVicar says, it has grown to be the fashion, to a marvelous extent, to give predominance in education to physical and mathematical studies over moral and mental. Hence a very general and growing prepossession in favour of material nature. Astronomy, natural philosophy, chemistry, natural history, geology, these and the like are in our day held to be everything. He continues:-

"Now, all these branches of study, however various in detail, agree in this, that they exclude the conception of a true self-directive power from the field of thought. They offer for consideration nothing but figures, movements, and laws. And thus they tend to form the popular mind to the habit of looking for figures, movements, and laws everywhere, and for rejecting all other conceptions as intruders. But of all such other conceptions, there is nothing so difficult and so intractable, under physical modes of investigation, as self-directive power. It therefore runs a great risk of being rejected, and thus the mind from its first training, having been in physics, carrying out here, as it usually does everywhere, its first love into all its after thoughts, shuts up the student surreptitiously with materialism as his philosophy. Thus it is easy to see how materialism should come to be a current opinion, when the popular education runs all in favour of physical pursuits. But if philosophy must yield to the demands of the logical faculty for an extreme simplicity, unity, identity, at the fountain-head of nature, it were more logical to regard those phenomena and laws named physical, such as the laws of motion, elasticity, gravitation, etc., as manifestations, when existing under certain limiting conditions, of substances or beings which have also in them, when not so limited, and when existing under certain conditions, ability to manifest self-directive power. That every body is compounded, constituted, or made up of molecules, is universally agreed. Every body is therefore a fit subject for analysis. But when any body is submitted to analysis in reference to its mere corporeity or bodily nature, that is, its extension and impenetrability, what do we ultimately arrive at? Do we not, in reference to the attribute of extension, arrive at particles, of which the physical limit is that they have at least ceased to be extended, and are but mere points in space? And as to the attribute of impenetrability, what do we in the last analysis arrive at, but the idea of a substance that can resist the intrusion into its place of other similar substances, and, therefore, ultimately, a centre of force. And thus, under a logical analysis, which must be admitted to be legitimate, it may be maintained that a body or chemical element resolves itself into a system of centres of force balancing each other at certain distances, and thus rendering the whole molecule or mass extended, as body is known to be. The elements

of body, therefore, are things of which these attributes are to be affirmed in the first instance, that they possess unextended substance and extensive power. But, if so, do they not touch upon the confines of the spiritual world to say the least? asks MacVicar; and the Newton whom he anticipated would give a *mecanique celeste* to mankind, solves the problem, answers the question by his discovery of the cerebelic stream or will-flow.

Body and spirit, one at the fountain-head, when rising into existence, form, as it were, the first breath of creation; for, as Sir Wm. Thompson says: "Life proceeds from life and from nothing else." They are the opposite poles of being and constitute the two principles by the harmonious interweaving of which the beautiful system of creation is constituted, and its economy worked out. Such a view, far from being contrary to the canons of science, is even the necessary complement of science. That unity, which is the last word of science, must always include two objects, existing in contrast of all. The law of couples, of opposites, of reciprocal action between two contracted yet homogeneous and harmonizing elements, each of which opens a field for the other, and brings it into action, is of universal extent. In the organic world, also, no less than in the purely physical and chemical, all is framed according to the same law of couples. In the sphere of sensibility, in like manner, everything turns on the antagonism of pleasure and pain, and in the moral sphere of good and evil. Nor is the world of pure intellect exempt from this law, but on the contrary displays its influence everywhere. Hence faith and sight, identity and difference, finite and infinite, objective and subjective, space and time, cause and effect, the world of realities and the world of ideas. In a word, every system of thought and of things, when complete, present as its basis two co-ordinate elements, the reciprocals of each other; or one parted into two reciprocally, and by the harmonious antagonism of both the beautiful web of nature is woven. If we are to be consistent, mind and matter ought always to be viewed as distinct, and the opposite poles of being; *inertia*, or unvarying submissiveness to the laws of motion being the characteristic of the one; self-directive power the characteristic of the other."

The universal analogy of science sanctioned MacVicar in the characteristic he thus arrived at as that of animated nature, for if inertia, or the obedience to pressures and impulses from without, be the characteristic of matter, then that which is needed as the other term to complete the couple is just what has been insisted on, viz., self-directive power, the power to cause pressure and impulses. Here is shown the symmetrical relation in which this power, when viewed as the characteristic of the whole animal kingdom (which plainly points to man, and culminates in human nature), places the animal in relation with the vegetable and the mineral kingdoms. Of mineral or crystals, the characteristic is simply self-imposing or *self-manifesting* power. They are, so to speak, merely insoluble seeds without an embryo. To this, *self-developing* power is added in plants, and forms their acknowledged characteristic. While of animals the characteristic, according to the view here advanced (the same seed-producing, self-developing, powers continuing) is *self-directive* power superadded. This relationship between these three kingdoms of nature is as homogeneous and symmetrical as is necessary to appear to be legitimate, and is a true expression of the other of nature.

Granting these two principles, the inert and the self-directive, the necessary and the free, we obtain the materials for a universe, without disputing the fact of human liberty and bringing into suspicion even the possibility either of morality or immorality. If man be really free as well as under law, in this union of body and spirit, then in human nature heaven and earth truly embrace each other; and no reason appears why, as the ages roll on, our own free thought may not have the run of universe. . . . What study then can be more replete with interest, what researches can possess more of fascination, than those which Mr. Keely's discoveries are preparing the way for?

The discoveries of Mr. Keely (demonstrated - as he is now prepared to demonstrate them) cannot be disputed, though his system may be called in question. With the humility of genius he calls his theories hypotheses, and his hypotheses conjectures. The solidity of the principles, as

laid down by himself, cannot be decided upon by others until he has brought to light the whole system that grows out of them. But it is time the public should know that the odium thrown upon him by the Keely Motor Company, he does not deserve. It is time that the Press should cease its sneers, its cry of "Crucify him, crucify him!" morally speaking, and extend to him that discriminating appreciation of his work and encouragement which the *New York Home Journal, Truth, Detroit Tribune, Chicago Herald, Toledo Blade, Atlanta Constitution, The Statesman*, and *Vienna News* have been the first to do. Let the Press contrast the past history of science with the present position of Keely, as Professor Dewar has done. Only such a man who knows from experience the labour, the difficulties, the uncertainties, attendant upon researching unknown laws of nature is able to appreciate all that is now being concentrated in the single life of one man. It is time that capitalists should step from their ranks to protect Keely from the selfish policy of the managers of a speculative company, which has long since forfeited all claims upon him, to continue mechanical work for it, even admitting that it ever possessed that right; and, more than all else, it is time that science should send her delegates to confer with the broad-minded men who have had the courage to give testimony, without which Keely could not have stood where, this year, he stands for the first time, fearless of threats, pursuing his researches on his own line, to acquire that knowledge of the laws governing his discoveries by which alone he can gain sufficient control of machinery to insure financial success. Meanwhile, are there no men who are able to feel an interest (without reference to commercial results) in a discovery which sweeps away the *debris* of materialism as chaff is swept before a whirlwind?-giving indisputable proof that, as St. Paul teaches, "we are the offspring of God;" or, as Aratus wrote, from whom he quoted:-

"From God we must originate,
Not any time we break the spell
That binds us to the ineffable.
Indeed, we all are evermore
Having to do with God: for we
His very kind and offspring be:
And to His offspring the benign
Fails not to give benignant sign."

From *New York Truth*, 3rd July, 1890.

"I think it is safe, for even the most conservative and pigheaded of scientists, to admit that Keely, the condemned, the scoffed at, the derided, the man whom every picayune peddler called charlatan because he could not harness the hitherto undiscovered forces of ether in less time than one might hitch up a mule, is the most original and the most straightforward of inventors, and that in his own good time he will give to the world a power that will throw steam and electricity into disuse, open the realms of air as a public highway for man, and send great ships careering over ocean with a power developed by sound. His theory of etheric vibration is now conclusively established, and it is only a question of time and material that delays its use as a servant to man. The fact is patent, so that he who runs may read, but the ox must have the yoke, the horse the collar, the engine the cylinder, and the dynamo the coil, ere they can work their wonders. While Keely was hampered by mere tradesmen, who only looked to the immediate recoupment of their outlay, men more anxious for dividends than discoveries, he could do little save turn showman, and exhibit his partial control of the harmonies of nature as springs catch woodcocks, and was forced to open his crude contrivances to divert the eternal will of the cosmos to work-a-day uses, that he might coax from the greed and credulity of mere mammon-worshipers the sorely grudged means to continue his exploration of the infinite. His genius was prisoned in a test tube, and only let out to play monkey tricks before muddle-headed merchants, who could see the effect, but not the means, and so the greatest discovery of the age was turned into a rare show, and the eternal music of the spheres was set, figuratively speaking, to play tunes to attract customers like a barrel organ before a dime museum."

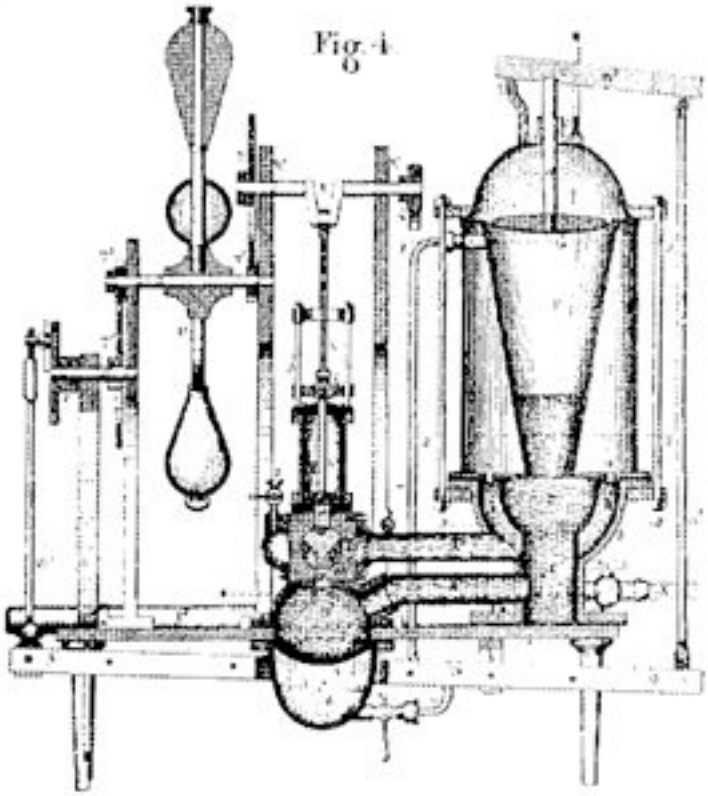


Fig. 1.
Witnesses.
Inventor.