Special Papers.

HIGH SCHOOL PHYSICS.

BY JAMES ASHER.

I WISH to correct a few errors in the new "High School Physics." Future editions of this good book should not have these faults. Besides, I wish to give some information and suggestions on steam and electricity.

Steam Engines.—The work says the motion of the slide valve is always opposite that of the piston. A cut shows the piston at one end of the cylinder, and the valve lets steam enter the port, which is wide open. The slide valve of an engine moves in part of its stroke the same way as the piston and in the rest the opposite way. The main crank is set at nearly a right angle to the crank or eccentric that moves the valve. In some engines the valve has partly opened the steam port when the piston begins its stroke; in others, it does not begin to open the port till the piston has moved a short distance. In the former the valve has positive, in the latter negative lead.

"The steam engine with all its merits and with all the improvements which modern mechanical art has devised is to-day a most wasteful machine. The best engine that has been constructed utilizes only 20 per cent. of the heat power used." This is not in accord with the second law of thermodynamics, which says the fraction of total heat which can be changed into mechanical work in a heat engine depends on the difference in absolute temperature between the initial and exhaust working fluid. The book makes a mistake, like calling as head the height of water in a penstock above the *bottom* of the tail race. The height of water in the penstock above the *surface* of tail water is the head. Estimates of a water wheel's efficiency are based on this fact. The miller may get more power by making a higher and stronger dam.

The fraction of total heat energy that could be changed into work by an ideal engine without friction and radiation is expressed by the difference in absolute temperature between the initial and exhaust steam taken as numerator and the absolute temperature of the initial steam as denominator. The absolute zero, the point at which a body would have no heat, the point at which the molecules of the body would not move, is nearly 460° below zero Fahrenheit.

Suppose an engine takes steam at 150 pounds pressure to the square inch and exhausts at 5 above vacuum. The temperature of steam at 150 is 358°, or 818° above the absolute zero. At 5 pounds pressure it is 162°, or 622° above the absolute zero. A perfect engine with these limits would give $\frac{818-622}{818}$, or 23.96 per cent of the total energy as work. If the best engine utilizes 20 per cent. of the total energy it is very economical, for it gives $\frac{20}{24}$ or more than 83 per cent. that of a perfect engine. The Risdon turbine, the first in first class water wheels at the Centennial test, gave 87.66 per cent. The best steam engine is as economical of its working fluid as a first-class turbine water wheel.

The economy of the boiler has not been noticed. A first-rate boiler gives an engine 75 per cent. of the energy in the fuel, 25 per cent. being lost in radiation and the hot gases passing up the chimney. If this loss be reduced a good draught cannot well be had.

The best way of adding to the economy of high class engines is to raise the difference in temperature between the initial and exhaust steam. As the temperature of exhaust cannot well be reduced we may raise the temperature and consequently the pressure of the steam entering the engine. Suppose we give steam at 400 pounds and exhaust at 5, the temperature of the former is 445° and of the latter 162°, or 905° and 622° above the absolute zero. An ideal engine would now give $\frac{905-622}{905}$ or more than 31 per cent. With live steam at 150 and exhaust at 5, we saw a perfect engine would not give 24 per cent. Therefore we gain much by using very high pressure steam. If the steam engine remain, 500 pounds to the square inch will soon be used. High pressures are as safe as low low pressures when the boilers are proportionately strong. The locomotive has 120, which is double that in the stationary engine. When did a locomotive in Canada explode? Among 70,000 locomotives in the world when did the latest explosion occur? Forty years ago the pressure rarely exceeded 14 pounds in marine engines; it is now 150 in the greyhounds of the Atlantic. Forty years ago the marine boiler used at least 10 pounds of coal to the hourly horse power; now one pound is used, and the ship's speed has been doubled.

The crank and piston, engineering barbarisms, will soon be abolished. The rotary engine will be used. Conceive a steam reaction turbine taking steam at the centre through its hollow shaft and exhausting at the circumference. The wheel will be enclosed by a neat case with only a pulley protruding. Very high pressure steam will enter and the engine will turn 2,000 times a minute. It will not cost half so much, weigh half so much, occupy half so much space, nor contain half so many parts as any other steam engine. Priming cannot ruin it; there will be neither cylinder, crank, piston, eccentric, balls, nor packing. There will be no dead points, hence it will start without help, and the angular velocity will be absolutely uniform at all points of the revolution. It will have no clearance space to waste steam, and there will be no friction but that of the bearings, hence only two places will need oil. In many cases no pulley will be used; a circular saw, a planer, or a dynamo may be fixed to the shaft.

The steam locomotive for lightning express trains may soon be an improvement on that invented two centuries ago by Sir J. Newton. His Explanation of the Newtonian Philosophy, says it will yet be necessary to travel 50 miles an hour, and shows a drawing of his proposed locomotive. It is a boiler and furnace on wheels, and a long steam pipe extends backward. The long pipe would lessen the speed of the steam and cause greater economy. The steam rushes backward and the locomotive forward on the principle of reaction. The long pipe may be replaced by a short one made into many elbows. Less metal will be required for each elbow lessens the speed of steam as much as would 40 diameters in length of pipe.

I shall explain the reaction. Suppose a vessel filled with high pressure steam, the vessel will not move while closed for the pressure on opposite walls inside balance each other. If a hole in the vessel be opened the pressure at the hole vanishes while that on an equal area of the opposite wall remains, hence there is an unbalanced backward push equal to what was on the covering of the hole. If the pressure was 150 pounds to the square inch, and the area of the hole one square inch, when open the steam would cause an effective backward pressure of 150 pounds. If the supply of steam equal the demand a steady backward pressure of 150 pounds will exist. The rocket, Hero's eolipile, Barker's mill, the recoil of a gun, many turbines, and the rotating lawn sprinkler depend on this elegant principle. It explains why steam boilers often fly many hundred yards after one end is blown out. Many wrongly think recoil depends on the issuing fluid's action on that in which the body moves. For example, they think the rise of a rocket is due to the push against the air of its hissing gases. It will rise faster in a vacuum than in air, for it will meet less resistance.

The express steam locomotive may yet be a boiler on car wheels, and the steam pipe will be many elbows on its back. The steam will exhaust backward through a strong, nearly horizontal smoke stack, increasing the draught of the furnace by steam. A branch of the stack will extend forward for backing. The whole force moving the train will be exerted against the pipe inside the smoke stack, the wheels have nothing to do with it. This engine may run 70 miles an hour. It will run smoothly on the rails, reciprocating motions will be absent, hence the damage to locomotive and track will be small, and high speeds far safer than at present. The driving force here does not depend on the adhesion of the wheels to the rails. The engine and cars will run as well on a greasy track. A similar boiler on runners will be a steam ice yacht.

Ships may be driven by recoil action of steam. B. Franklin, a century ago, made such an experiment. He made steam from a boiler on a boat pass backward through a pipe into the water. It failed for he used low pressure steam. Steam ships will have boilers but no engine; the steam after passing through many elbows will be blown into the sea through two pipes, one on either side of the stern post near its base. Two pipes will also extend forward, one on either side of the bow, for backing. The ship can be turned to the right or left by setting a valve to make less steam pass through one pipe than the other. There will be no engine to get out of order, neither screw nor rudder to lose in the storms of mid-ocean.

(*To be completed in next number*).

For Friday Afternoon.

A COLLOQUY ON THE CANADIAN SHORE.

(FROM PUNCH.)

Canada—
"Westward the course of empire takes its way."
Britannia—
The Bishop's famous line, dear, bears to-day
Modified meaning; westward runs indeed
The route of empire—ours!
Canada—
If I succeed
In drawing hither Trade's unfaltering feet,
And *yours*, my triumph then will be complete.
Britannia—
Across your continent from sea to sea
All is our own, my child, and all is free.
No jealous rivals spy around our path
With watchfulness not far remote from wrath.
The sea-ways are my own, free from of old
To keels adventurous and bosoms bold.
Now, from my western cliffs that front the deep
To where the warm Pacific waters sweep
Around Cathay and old Zibangu's shore,
My course is clear. What can I wish for more?
To your young enterprise the praise is due.
Canada—
The praise, and profit, I would share with you.
Canadian energy has felt the spur
Of British capital; the flush and stir
Of British patriot blood is in our heart;
Still I am glad you think I've done my part.
Britannia—
Bravely! Yon Arctic wastes no more need slay
My gallant sons. Had Franklin seen this day
He had not slept his last long lonely sleep
Where the chill ice-pack lades the frozen deep.
"It can be done; England should do it!" Yes,
That is the thought which urges to success
Our struggling sore-tried heroes. Waghorn knew
Such inspiration. Many a palsied crew
Painfully creeping through the Arctic night
Have felt it fill their souls like fire and light.
Well, it *is* done, by men of English strain,
Though in such shape as they who strove in vain
With Boreal cold and darkness never dreamed
When o'er the Pole the pale aurora gleamed
Perpetual challenge.
Canada—
Here's your Empire route!
A right of way whose value to compute
Will tax the prophets.
Britannia—
Links me closer still
With all my wandering sons who tame and till
The world's wild wastes, and throng each paradise
In tropic seas or under southern skies,
See, Halifax, Vancouver, Sydney, set
Fresh steps upon a path whose promise yet
Even ourselves have hardly measured. Lo!
Far China brought within a moon or so,
Of tea-devouring London! Here it lies,
The way for men and mails and merchandise.
Striking athwart your sea-dividing sweep
Of land; one iron road from deep to deep!
Well thought, well done!
Canada—
No more need you depend
On furtive enemy or doubtful friend,
Your home is on the deep, and when you come,
To the Dominion's land you're still at home.
Britannia—
And woe to him the Statesman cold or blind,
Of clutching spirit or of chilling mind,
Pedantic prig or purse-string tightening fool,
Who'd check such work and such a spirit cool!
Yours is the praise and may the profit flow
In fullest stream, 'midst your Canadian snow
A true Pactolus. Trade's prolific fruit,
Should freely flourish on our Empire Route.