14. If L_m be the mutual induction between the high potential primary and the secondary and aerial, L_1 be the total induction in the primary, L_2 the total induction in the secondary and aerial.

The factor $\frac{L_m^2}{L_1 L_2}$ is called the "Coupling Factor" or the "Coupling."

When this factor is large, the coupling is said to be "Strong," "Tight," or "Heavy." When it is small, the coupling is "Weak," "Loose," or "Light." The coupling plays a very important part in the system.

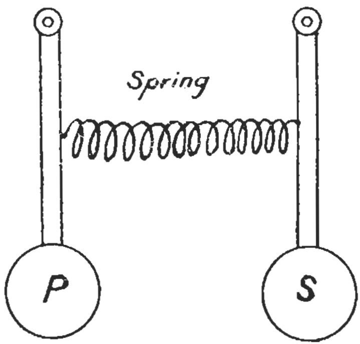

FIG. 38.

Imagine two pendulums P and S connected by a spring (Fig. 38). If we set P oscillating, the energy of P's motion will be conveyed by the spring to S. If the spring is weak, it will require several oscillations of *P* to start S fully swinging, and any resistance to *S*'s swing will not be much felt by *P*.

With a loose coupling it takes some time for the energy to get from the primary high potential circuit to the secondary and aerial, and the losses in the aerial do not greatly affect the system. That is to say, the most important losses take place in the primary.

Thus a weak spring in Fig. 38 is analogous to a loose coupling.

If the spring in Fig. 38 be strong, *P*'s motion is instantly conveyed to *S*. If any opposition to S's movement is made, both *P* and *S* are instantly affected. Similarly with a tight coupling, the energy is conveyed instantly from primary to secondary, and any loss in the secondary is most important.

To carry the analogy further, suppose we stop the oscillating force on *P*. With a weak spring the oscillations of *S* will continue and will keep *P* oscillating for some time. With a loose coupling, when the spark stops, energy is still being radiated and is even given back to the primary, to be again returned when the next spark takes place. But with a strong spring when the oscillating force is removed, although *P* and *S* will still continue to oscillate for a short time, they will stop simultaneously. With a tight coupling we get a similar effect.

15. With a tight coupling the insulation of the aerial, size, brushing effect, connection to earth, &c., are of the greatest importance. With a loose coupling they are second in moment to the losses caused by the primary circuit, such as resistance of spark-gap and leads, hysteresis of condenser, and so on.

Another analogy is useful as an assistance to remembering this.

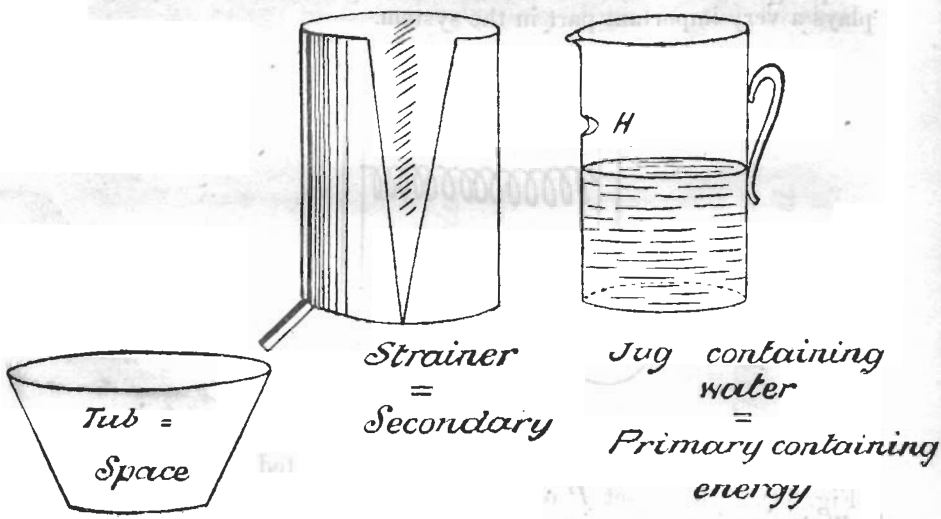

Fig. 39.

Fig. 39 represents the circuit. The primary is a jug containing water. This jug has a hole *H* in it. *H* represents the resistance of the spark-gap and leads, and the hysteresis of the condensers. The water is the electrical energy.

The secondary is represented by a strainer which has a V-shaped slot in it. This V-shaped slot represents the resistance of the aerial and brushing. The tub represents space.

Imagine a man who wants to get as much water as possible through the strainer into the tub. This is analogous to the problem set to the electrical engineer, who has to get as much energy into space as he can.

If the man pours the water very slowly, a lot will escape through the hole *H*, but not much through the V-shaped slot, as it will run from the strainer into the tub almost immediately.

This is analogous to a loose coupling.

On the other hand, if the man up-ends the jug into the strainer, very little water will escape through *H*, but a good deal through the V-shaped slot.

This is tight coupling.

16. As a general rule it is easier to keep the losses in the primary down. Hence, when only a small power is available a loose coupling is better.

With plenty of power but a limited aerial, a loose coupling becomes a necessity. In ships the aerial is the factor that decides the power available.

17. Although there are three waves in all oscillatory systems, only two are of any importance.

If Y be the natural wave-length of the primary circuit, and the secondary circuit is placed in resonance with it, then—

$$Y_1 = Y(1 + \sqrt{C})$$
$$Y_2 = Y(1 - \sqrt{C})$$

where Y_1, Y_2 are the two important waves, and C is the coupling.

Thus, if the coupling is loose, Y_1 and Y_2 are very nearly equal, or the two waves do not differ much in length.

If, however, the coupling is tight (over $\frac{1}{2}$), they differ considerably.

18. Losses in the Aerial.—The principal loss in the aerial is due to brushing. Wherever there is a sharp point, the surface density when the aerial is charged is very high indeed, and a thin stream of electric particles is constantly flowing out. This is particularly so at the top ends of the aerial, where the potential is highest. A good method of getting over this is to use rounded ends. The aerial ends at Poldhu, for instance, are brought to curtain rings.

It must be remembered, though, that this is the point where an aerial and a lightning conductor differ. A good lightning conductor has many sharp points, its business being to discharge the earth into the atmosphere. A good aerial has no points at all, as its duty is to keep the energy given to it in the form of oscillatory currents up and down it. It must not allow of escape to the atmosphere. Stranded wire necessarily causes a greater surface density than smooth wire. Thus, for aerials single strands are better.

19. The resistance loss in an aerial is never very great, but it is as well to remember that it is there. The point where resistance is likely to come is at the earth terminal. This must be carefully looked after and kept thoroughly clean.

20. In the primary circuit the resistance is an important matter. Brass tubing is a good thing for connections and is used for *C* tune. Oscillatory currents do not travel through the whole section of a thick wire. They only penetrate a very small thickness from the surface.

The place where the most resistance is met is the spark-gap. Hence, too long a spark is not always a good thing. On a plain aerial, 180 feet long, there will be little increase of energy caused by increasing the spark after 5 cm., if not positive loss.

21. Hysteresis in the condenser is also a cause of loss.

22. Brushing in the primary usually takes place in the condenser. It is very noticeable when a big spark is being used for *B* tune. With the ordinary Leyden jar any damp causes an instant increase in the brushing. For this reason oil condensers are used with big power. Mr. Marconi is trying some compressed air condensers, but great precautions are taken to prevent moisture getting in.