On deep rivers with considerable currents these difficulties have been found to be of no practical importance. In bends the current greatly assists the steering power of the tug, throwing the vessel powerfully towards the outside of the curve, and thus counteracting the tendency of the rope to pull it towards the inside. This not only helps to keep the boat in its proper water-course, but assists also the action of replacing the rope in its correct position. With regard to kinks, the considerable depth through which the back rope has to sink down from the last guide pulley to the bottom of the river regulates up to a certain point the delivery of slack rope. The greater speed admissible on deep rivers finally increases the steering and staying power of the tug All this is different on shallow rivers and canals, with their sharp and frequent bends, want of current, and slow admissible speed. Here the difficulties of kinks in the slack rope, the want of steering power, the consequent impossibility of replacing the rope in its original position when displaced by the direct pull of the tug, and therefore the incapability of the tug to round sharp curves readily, after a few working trips, have proved, up to lately, fatal to the introduction of wire-rope towing. What appeared to be required was greatly increased steering power, the tug being more or less independent from the tightness of the wire-rope, and the maintenance of a uniform state of tightness in the rope, which on the one side would entirely avoid kinks in slack rope, whilst on the other it would not unduly interfere with the movement of the vessel in curves.

The principle embodied in Messrs. Greig and Eyth's patent offers the most simple solution of this problem. The rope, after passing the clip-drum, instead of sinking back into the water, is led over one or more "moving sheaves" of an apparatus which, altogether, is called the "slack gear." The motion of this moving sheave away or towards the clip-drum along a pair of horizontal rails of sufficient length causes a greater or smaller amount of wire rope to be stretched between clip-drum and sliding pulley, and this rope is constantly kept at a certain uniform tightness by the pressure of the piston of a steam cylinder being brought to bear on the moving sheave. Thus it becomes evident that instead of any slack rope leaving the tug, it is retained on board stretched out between the clip-drum and moving sheaves, the rope, leaving the tug under all circumstances with a moderate and uniform strain on it, avoiding every chance of kinking. On the other side, whenever the wire rope has a tendency to become too tight, the sliding pulleys recede towards the clip-drum, paying out some of the stored up rope, and restoring the original moderate tension in the back rope. It is evident how far this arrangement influences the steering and staying powers of the tug As long as the slack gear has any rope to spare the tug is not held by the back rope, and can move laterally with perfect freedom. If, combined with this, the distance from the first to the last guide pulley is of moderate length, the tug will be with regard to its steering power almost independent of the rope. There being no kinks possible and no loose ropes to contend with, the cable can now without danger be led over the centre of the vessel. The rope itself will be saved not only from kinking, but also from any undue strains which formerly were put on it whilst steering round curves, and which frequently made the towing round sharp bends an impossibility.

We now describe in detail the special canal tug illustrated on page 136 On most canals it is highly desirable that the tug should be able to run back and forward along the rope without turning, and to reverse its course with as little trouble and loss of time as possible. This makes the general arrangement of tugs for canal navigation proper, somewhat more complicated than that of river tugs, the latter being required to run forward only when at work, and to turn round at the end of their journey. Bow and stern of the vessel are therefore of exactly the same shape, each end being provided with a long and powerful rudder worked independently from the deck near the centre of the boat by a separate wheel. The front rudder is generally fixed in its central position, thus forming a prolongation of the keel and increasing the staying power of the vessel to a very considerable degree. The middle portion of the boat is occupied by the engine-room, and therefore provided with a deck of sufficient elevation. Towards both ends the deck is considerably lower, sloping down towards the rudder-posts, where it is only a few inches above the water line. This lower portion of the deck is made absolutely water-tight, and the space below it is specially occupied by portions of the slack gear. Above the rudders, for the sake of protecting them and of preventing the wire rope interfering with their movements, there is a sort of raft actually floating on the water, and thus in no way increasing the draught of the vessel, but at the same time firmly bolted to its sides. These rafts increase the steadiness of the boat, and protect it efficiently in case of collisions. In the centre of the engine-room, placed crossways, is a tubular boiler carrying a double-cylinder engine of about 8 to 10-horse power. The engine is fixed on the side of the fire-box and boiler barrel, so that the crank shaft is in a vertical position, near the smoke-box end. The smoke-box is a accessible through a corresponding opening, protected by a water-tight cover in the side of the boat. The starting and reversing handle of the engine are on deck, in easy reach of the helmsman, whilst the stoker fires the boiler from the side. The crank shaft at its upper end carries a small fly-wheel, at its lower end a pinion, working the clip-drum, which turns horizontally on a shaft underneath the boiler, and is otherwise in such a position that the centre line of the clips touches the centre line of the boat. Below and above the clip-drum there are—loosely turning on the same shaft—two ordinary rope sheaves, which we shall call the top and the bottom centre sheave respectively.

On each side of the boiler is a "moving sheave," *i.e.*, a rope-pulley, turning horizontally on a vertical stud, which is bolted to a strong flat iron carried on rollers, and thus capable of moving along a rail from the clip-drum towards the rudder-post, through very near the whole length of the vessel Attached to each end of the wagon on which the sheave rests there is a chain, which by suitable pulleys is led along the rail, and then towards the chain drums, to which the ends are fixed.

Chain-drums and slack-gear cylinders are shown on an enlarged scale. The slack gear cylinder is simply a tube, the ends being closed by two pistons. Between the pistons is an opening provided with a three-way cock, by which the interior of the cylinder can be placed in direct communication with the boiler or with the atmosphere When the slack gear is in action the boiler pressure is directly and constantly acting on the two pistons. There are toothed piston-rods to these pistons, acting like a rack and working a pinion. The pinion is keyed to a short shaft which also carries a chain drum. Each chain drum acts on one of the moving sheaves above described, the two chains coming from opposite ends of the wagon, being wound on the drum from opposite sides, so that the turning of the drum winds one chain on whilst unwinding the other, and thereby moves the sheaves wagon back or forward. The steam pressure in the slack gear cylinder constantly pressing the two pistons outwards, produces evidently a tendency to turn the drums, or, by means of the chains, to push the sheaves from the clip-drum away towards the boat ends. The opposite motion would be accomplished by pressing the sheaves towards the clip-drum with a power sufficiently great to overcome the steam pressure in the cylinder and to push the pistons back into it. A catch and a ratchet—the latter being cast to the top flange of each chain drum—are used for stopping the motion of the drums, whenever it is desirable to stop the action of the slack gear and work with a fixed or rigid system of pulleys. The two catches are connected by a link, and the handle by which they are thrown in or out of gear, as well as the handle by which steam is admitted to the slack gear, are both in reach of the helmsman. We have finally to mention a pair of vertical guide pulleys, leading the rope into the clip-drum, and two swinging pulleys the latter being the first and the last pulley over which the rope runs in its passage through the boat. They are suspended by a universal joint, which permits them to assume any angle indicated by the direction of the rope, and their position near the centre of the boat, and very little above the water-line, offers great advantages as to the handling and steering of the boat in curves. The rope is prevented from surging over the slanting decks by the strain which is constantly put on it, in front by the actual work performed, behind by the action of the slack gear.

Following now the rope in its passages over the tug, we see it passing over the first swinging pulley, down towards and slightly round the vertical guide pulley, half round the clip drum, towards and half round the moving sheave A—back again, passing underneath the boiler towards and half round the moving sheave B; once more back and half round the top centre sheave, and from thence underneath the second guide pulley over the second swinging pulley back into the water.