no difficulty in stopping the span before coupling up to the mooring trusses.

The time of arrival will be controlled by the tugs so that the span will be in position about half an hour after high tide, when, for a period of 1 hr., the current does not exceed 3 miles per hr. and during which it changes direction. The tugs will hold the span against the wind and current while the 1¼-in. steel mooring lines are being connected, as shown in figs 3 and 4. The span will then be pulled directly under its final position in the bridge by means of these 1¼-in. mooring ropes, eight in number, two connecting at each corner of the span. At the end of each rope is a loop which, as soon as the span has come within reach and the speed is controlled, will be thrown over a double-headed cast-steel snubbing block or towing bitt, bolted to a seat provided at the joint XLO of the suspended span. Each 1¼-in. rope is calculated to take a pull of 75,000 lb. The ropes pass through sheaves at the lower corners of the mooring trusses and from there run vertically to the trusses, where they connect to a nine-part ¾-in. wire rope tackle, which leads back to the drums of the derrick hoists, situated on the floor at the ends of each cantilever arms.

With one line out on each end, the load for a 7-mile current and 1-lb. wind (77,500) would be carried. With two lines cut (second position, fig. 3) the upstream pull of 145,000 lb. would provide for a 7-mile current and 6-lb. wind (145,-000 lb.). With all four out at each end, a 220,000-lb. force could be exerted to overcome a 7-mile current plus an 11½-mile wind (219,000 lb.). In final hoisting position the upstream force becomes 121,000 lb., which is good for a 7-mile current and a 4-lb. wind. By transferring line 1 to bitt 2 in the third position a 7-mile current and a 17-lb. wind (293,000 lb.) would be overcome; by transferring line 4 to bitt 2 in the final position a 7-mile current and a 9-lb. wind (186,000 lb.) could be provided for.

The mooring frames, as shown in figs. 2 and 4, are made of two steel trusses with bracing and are suspended from the cantilever arm floor beams at panel point CF1. They are hung at the upper ends so that they can be swung back, in order not to obstruct the channel unnecessarily, practically up against the plane of the bottom chords of the cantilever arms, by means of a nine-part ⅞-in. wire-rope tackle leading from the lower corners of the trusses to the connection to the floor between panel points CF5 and CF6 of the cantilever arms and from there to the main hoists, situated at the floor level of the cantilever arms and on the centre line of the bridge. These trusses and their connections throughout were designed to take a transverse pull from the suspended span of 300,000 lb.

As soon as the span is pulled into position, before being lifted from the scows, the hanger chains will be swung down and connected through the slotted holes at the lower end to the pins at the top of the short hanger link, shown in fig 5, connecting to the supporting girders under the joint XLO. These hanger chains at each corner of the span are made up of 4 strings of slabs to each chain. Each slab is built up of two 30 x 1⅛-in. carbon steel plates. The allowable working erection unit stress through the pin holes was 20,000 lb. per sq. in., which included the stress from 20% of the lifted load as impact. No reinforcing pin plates were used around the pin holes, and special tests made showed that this apparently high working stress through the pin holes was perfectly safe for this type of connection. The slabs were manufactured and shipped in lengths of about 30 ft. c. to c. of end pin holes. They were controlled after being suspended from the jacking girders by means of a two-part tackle connecting to the cantilever arm trusses at panel point CL2. The hanger chains connect at the lower end to supporting girders, shown in fig. 5. These supporting girders are 6 ft. 11½ in. back to back of angles and 25 ft. long. They are built up of two plate girders, connected together by bearing stiffening and pin connection diaphragms and also by cover plates. The load of the suspended span is transmitted to the girders by means of a cast steel rocker joint, designed to allow turning about the transverse and longitudinal axes of the bearing.

The upper supporting girders at the CUO joint of the cantilever arm are designed in a similar manner to the lower supporting girders, the rocker bearing for the girders and the pin connection for the vertical hangers allowing turning about both the transverse and longitudinal axes of the supporting girders. With bearings of this design the suspended span may move in any direction under the influence of whatever external forces from wind or current may act on it during the hoisting of the span. The total load carried by the hanger chains while lifting the span is 5,147 tons. The supporting girders, hanger chains, jacks and jacking girders and all their connections are designed throughout to carry this lifted load plus 20% impact.

As shown in fig 5 the jacking girders are located at the same elevation as the floor of the cantilever arm. They are hung from the upper supporting girders by stiff hangers that are pin connected at the upper and lower ends. At the lower ends these stiff hangers are attached to guides built of plates and angles that pass through the upper jacking girders and are riveted into the lower jacking girders. The position of the lower girders is therefore fixed, and their distance from the panel point CUO does not change during the jacking operation. The upper girders are the movable girders, and they slide up and down the guides as the 1,000-ton jacks are operated. These jacks are placed between the upper and lower jacking girders 2 at each corner of the span, and do the work of lifting the span. In order to avoid binding of the jacks, due to the deflection of the jacking girders under load, the jacks are provided with rocker seats at their upper and lower bearings. They are located at the extreme ends of the jacking girders, where they bear against transverse diaphragms riveted into the jacking girders.

In addition to the hydraulic jacks, following up screw jacks are provided as a safety device in case anything should go wrong with the pumping system for the hydraulic jacks or the jacks themselves, if they should fail to maintain the pressure of about 4,500 lb. per sq. in. necessary to hold the weight of the suspended span while being lifted. These screw jacks also react against cross girder diaphragms in the jacking girders. The screw itself is counterweighted so that practically all the friction due to its own weight is eliminated, and the operator of the screw jacks will be able to turn the screw without difficulty and follow the operations of the hydraulic jacks with equal speed and very little exertion.

The hanger lifting chains are guided between cross pin bearing diaphragms riveted into the jacking girders. These chains are bored every 6 ft. c. to c. to receive a 12-in. pin while the cross diaphragms have holes for the same diameter of pin bored at 2 ft. centres. The clearance provided in the pin holes of the hanger chains is ½ in. transversely and ⅞ in. longitudinally, and in the pin holes of the cross-diaphragms 1 in. transversely and 1¾ in. longitudinally. This clearance is considered ample to allow the pins to be driven, no matter what position the span may take while hoisting, due to the action of current and wind. Having the pin holes in the cross diaphragms at 2-ft. centres enabled the pin holes in the hangers to be bored at 6 ft. centres and at the same time accommodated the 2 ft. stroke of the jacks.

Each operation of the jacks will lift the span 2 ft. During the lifting or upward stroke, the 12-in. pins engage the hanger chains through the diaphragms in the upper jacking girders. At the finish of the stroke the pins are entered in the diaphragms of the lower jacking girders to engage the hanger chains. The upper pins are then removed, the jacks and upper girders lowered, the upper pins again entered, the lower pins removed and jacks again operated. As each 30 ft. length of hanger chain passes up through the upper jacking girders it is disconnected and removed. The jacking pins are counter-weighted and balanced to enable them to be handled with facility by the men on the operating platform.

The jacks are supplied with water under pressure of about 4,500 lb. per sq. in. by a pair of direct acting double-plunger pumps, operated by compressed air and located on the centre line of the bridge floor at the ends of the cantilever arm. By means of a pair of control valves installed in front of the pumps the supply of water sent to each corner of the span can be regulated, and in this manner with the aid of a simple counterweighted line indicator in front of the valve operator, which will show any difference in level between the lifting girders on each side of the bridge, the two corners of each end of the span can be kept at the same elevation. Another set of valves with a similar indicator is placed on the operating platform in front of each set of jacking girders to control the water supply to each separate jack, so that the ends of the jacking girders, during jacking operations, can be kept level. The feed-pipe line is connected to the jacks by means of two ⅜-in. copper pipes which are sufficiently flexible to allow for any swaying motion of the span while being hoisted.

Tests of the complete water feed pipe lines and hydraulic jacks were made under a pressure of 6,000 lb. per sq. in. The jacking girders were tested with a load on the jacks equal to 5,000 lb. per sq. in. pressure. The working load on these jacks would be about 4,500 lb. per sq. in. Each individual scow was tested for leakage after the scows were in place.

The vertical distance through which the span will be hoisted depends upon the varying elevation of the water level, but will be approximately 145 ft. Each operation of the jacks hoists the span 2 ft., and a cycle will take about 15 min. to complete. Altogether there will be approximately 73 separate lifting operations, and the time consumed from the moment of coupling up to the hanger lifting chains to the moment of driving the last pins connecting the two portions of the permanent eye-bar suspenders will be approximately 20 hrs., provided no delays occur.—Engineering News.