A Reference Target Frame and Fish Deflection Weir for Fixed-Location Riverine Hydroacoustic Systems

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A REFERENCE TARGET FRAME AND FISH DEFLECTION WEIR FOR FIXED-LOCATION RIVERINE HYDROACOUSTIC SYSTEMS

by

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ABSTRACT

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The riverine environment presents unique difficulties for operating fixed-location hydroacoustic enumeration sites. In systems with moderate to fast flows fish tend to migrate along banks and are bottom oriented. Bank-mounted transducers are therefore liable to encounter interference from fish migrating through the near-field of the transducer. High currents and turbulent flow make calibrations and experiments using acoustic targets difficult to perform. To address these problems we constructed a deflection weir and target frame for use with a split-beam hydroacoustic system. The deflection weir forces fish to migrate through the acoustic beam at a distance well beyond the near field. The target frame holds targets stationary within the acoustic beam, making calibrations and experiments possible. The diversion weir and target frame also have application to single and dual beam hydroacoustic systems.

RÈSUMÈ

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L'environnement riverain pose des difficultés particulières à l'exploitation de sites d'énumération hydroacoustique fixes. Dans les zones à écoulement moyen ou rapide, les poissons ont tendance à se déplacer le long des rives et à s'orienter vers le fond. Les transducteurs installés sur la rive peuvent donc subir des interférences provoquees par les poissons traversant le champ proche. Les courants importants et les turbulences compliquent beaucoup l'étalonnage et les essais avec cibles acoustiques. Afin de résoudre ce problème, nous avons fabriqué une chicane servant à éloigner les poissons et un cadre à cibles pouvant être utilisé avec un système acoustique à faisceau divisé. La chicane force les poissons à traverser le faisceau acoustique à une distance bien supérieure à celle du champ proche. Le cadre permet de maintenir des cibles en place au sein du faisceau acoustique et ainsi de réaliser des étalonnages et des expériences. La chicane et le cadre à cibles peuvent être utilisés avec des sytemès acoustiques à faisceau ou double.

INTRODUCTION

Hydroacoustic systems are widely used in lakes and seas to estimate fish population sizes. It is only in recent years that fixed-location hydroacoustics have been applied to rivers and streams to estimate the numbers of fish migrating upstream.

The riverine environment poses several difficulties for fixed-location hydroacoustic enumeration. Fish migrating upstream tend to be bank oriented in rivers with moderate to high currents. This is because flow rates are lower near the bank and are easier for fish to navigate. Since the acoustic transducer is also located near the river bank there exists the potential for fish to migrate through the near-field of the transducer and be undetected. To eliminate this potential we designed and constructed a track-mounted weir that diverts fish away from the river bank and beyond the transducer's near-field. The track system solves several problems associated with the riverine environment. First, it allows us to easily lower or raise the weir up and down the river bank to accommodates to fluctuating water levels. Second, it eliminates the hassles of a free standing weir which would be difficult to manoeuvre even in low current regimes and hard to anchor in the substrate.

Standard target calibrations are essential for determining the operating parameters of hydroacoustic equipment. In still bodies of water, standard target calibrations can be done by suspending a stationary target on a line, into the acoustic beam. In the riverine environment it is difficult and often impossible to suspend a stationary target in the beam since currents and turbulence can cause the target to sway erratically. To overcome this difficulty we constructed a target frame to which we can secure a variety of targets. In addition to standard target calibrations we use this frame for acoustic experiments and for aiming the acoustic beam in a repeatable configuration.

This paper presents the design and rationale of a diversion weir and target frame system for use with a riverine hydroacoustic system. We presently use this system at a split-beam hydroacoustic site on the Fraser River 15km upstream of Hope, British Columbia, Canada, to enumerate migrating salmon stocks.

1. DEFLECTION WEIR

1.1 CONSTRUCTION

The fish deflection weir is a free-standing structure supported by a brace system connected to a double track that runs perpendicular to the river flow. The weir connects to the track at 4 positions, each made up of a roller assembly that allows the weir to move freely up and down the track. A catwalk with handrail runs along the top of the weir providing foot access along it's length. The entire structure can be divided into three functional groups (drawings are available from the authors): First, the diversion weir and bracing system built to withstand strong currents and prevent fish from migrating under or through it. Second, the carriages that attach the weir to the tracks and allow the weir to roll freely along the length of the track. Third, the track system that interfaces with the carriages and supports the weir.

A schematic of the weir panel, bracing, carriages, and walkway with handrail are shown in Fig. 1. The weir panel is trapezoidal to conform to the bank slope and is constructed entirely of aluminium. We used 7.62 x 7.62 x 0.95 cm angle for the main frame and 1.9 cm (schedule 80) pipe welded on 5.4cm centres vertically spaced along the length of the panel. The walkway (0.5m x 6.1m) is constructed of commercially available ***"Shur Grip"*** safety grating, supported by the weir bracing. The weir bracing consists of a series of steel pipes with bolt flanges welded to each end. The brace members are bolted together and to the weir panel to form a single unit joined to both tracks. The braces that join the top of the weir to the downstream carriages are constructed of 5.08cm steel pipe. The rest of the bracing and handrails are constructed of 3.81cm steel pipe. The heavier diagonal bracing provides additional strength to withstand the force of the river current on the weir panels.

Fig. 2 shows an exploded view of a track section and carriage assembly. Carriages lock onto the track and provide a roller surface for deploying the weir. Each of the four carriages is constructed of 1.27cm steel plate, housing eight rollers, and covered by 16 gauge stainless steel cowlings. Rollers are constructed from 3.81cm long polyethylene rod, machined to 3.81 cm diameter. The track consists of 7 sections of 8.89cm square tubing (0.635cm wall) in 3.66m lengths, for a total length of 25.6m. Each length is welded on a diagonal to a flat bar 3.81 x 1.27 x 15.24cm. Every 1.83m along the length of the track, the flat bar is welded to a bearing plate 1.27 x 15.24 x 30.48cm. The height of the flat bar allows the bottom of the carriage to travel between the track section and the bearing plate. Each bearing plate is bolted to a steel channel track tie (C150 x 30.48cm x 2.44m) to maintain a 1.83m spacing between the track sections. Track ties are anchored to the river bottom in seven evenly-spaced positions with steel rebar pegs (1m long x 1.59cm diameter). Each peg has a chain link welded to the top so that it can be pulled from the substrate if necessary.

1.2 DEPLOYMENT

We cleared all large boulders and debris from the region of the river bank where echosounding occurs and laid down flattened sand bags to form a smooth ramp approximately 27m long by 6m wide that conforms to the 24º slope of the natural river bank. This ramp allows us to aim the acoustic beam close to the river bottom without obstruction. The deflection weir and tracks run along the downstream side of the ramp. The weir is restricted from moving past the end of the tracks by metal plates. On the end nearest the river bank it is connected by a length of rope to a rope puller which is anchored to a boulder further up the bank. We use the rope puller to position the weir along the tracks. Fig. 3 shows side, top, and front views of the diversion weir and track.

Since the weir is fixed in the upstream/downstream direction, we are able to use it as a reference point for deploying the acoustic beam in a precise configuration with respect to the river bottom, shore, and weir. This is important for ensuring valid comparisons of data collected over the season. For example, if fish are seen to be distributed lower in the beam during a certain period, we know that they did in fact move lower in the beam and not simply that the system was aimed closer to the river bottom. The steps taken for deployment of the system are as follows: We lower the weir into the river using the rope puller so that the surface of the water lies just below the weir walkway. We then anchor the transducer pod into the sand bag ramp, about 1.2m upstream from the weir and 1 to 2m from the bank-end of the weir, with the top of the transducer about 0.5m under the surface of the water. This leaves approximately 4m from the face of the transducer to the river-end of the weir. As fish migrate up the river they are forced to navigate around the end of the weir. Thus, they pass through the beam at no less than 4m from the face of the transducer. This distance prohibits fish from entering the near field of the transducer and also ensures that the beam width is adequate to cover the region of the water column in which the fish are migrating.

The ability to lower and raise the weir is important since the river level can fluctuate greatly during a season. At our site on the Fraser River we usually need to lower the weir and transducer pod, and re-aim the acoustic beam daily to accommodate to dropping water levels. The introduction of the tracked weir system reduced the time required for this process from 1-3 hours to approximately 20 minutes. The tracked weir also serves as a reference for aiming the acoustic beam in a repeatable configuration.

2. REFERENCE TARGET FRAME

2.1 CONSTRUCTION

Side, front, top, and three-dimensional views of the reference target frame are shown in Fig. 4. The reference target frame is a rectangular aluminium frame which attaches to the river-end of the diversion weir perpendicular to the upstream side. The attachment site consists of a hinged slide receiver that fits over a "T" bar holder bolted to the weir. Targets attach to a cable and pulley system connected to offset bars welded to the top and bottom of the frame. The offset bars project towards the river bank and provide a range separation of 0.61m between the frame and target. This keeps the target forward of any turbulence created by the current passing around the frame. The frame is held steady in the current by a stabilizer bar mounted on the downstream top offset bar and hooked into the walkway.

All aluminium pipe used on the frame is Schedule 80. The main frame is constructed of 2.54cm pipe with mitred and welded corners. Gussets (1.27cm x 17cm pipe) are welded on both bottom corners to stiffen the structure. The bottom offset bars are made of 2.54cm pipe welded together to form a 24° angle that conforms to the river slope. The top offset bars are made 2.54cm square tubing providing a flat mounting surface for a tape measure. These bars are welded to the frame at a 90° angle. Movements of the target are recorded directly from the tape measure. Pulleys are made of 6.35cm polyethylene rod with a groove lathed in the centre to fit 0.16cm galvanized cable.

Fig. 5 shows the slide receiver and hinge holder that attach the weir and frame together. The hinged portion of the slide receiver is made of 1.27cm pipe and joined with a 1.27cm hinge pin. Hinge pin holders are welded to both sides making the frame reversible for operation on either bank. The slide receiver is constructed of 2 pieces of 2.54 x 2.54cm x 182cm aluminium tubing joined by two pieces of 3.81 x 3.81 x 182cm aluminium angle. This configuration forms a "T" shaped cavity capable of sliding over the 5.08 x 5.08cm "T" bar that is attached to the weir.

2.2 DEPLOYMENT

We use the target frame to perform standard target calibrations and hydroacoustic experiments. The frame holds an acoustic target in the river current with a minimum amount of target motion. Fig. 6 shows the configuration of the weir, frame, and acoustic beam during a standard target calibration.

In situ calibration using a standard target of known target strength, gives an overall performance check of a hydroacoustic system (Mitson 1983). To perform standard target calibrations, we attach a -39.55 dB tungsten carbide sphere to the vertical target wire. We then lower the frame into position on the end of the diversion weir. Next, we centre the acoustic beam in the frame and lower the target on the vertical target wire until it is in the centre of the beam. After collecting data, we compare the known target strength with the recorded target strength. Large differences between these two values indicate that a change has taken place in the transmit or receive performance of the system (Thorne 1983).

The split beam system gives the location of a target in the ensonified zone (Ehrenberg 1982). With this information we can determine the detection efficiency of a given transducer as a function of location in the beam cross section. To do this we attach a target with a target strength similar to the fish being surveyed (≈ -28 dB) to the target frame and lower the frame into position at the end of the weir. We centre the acoustic beam in the target frame and then position the target over a set of pre-determined grid points that cover the entire cross-section of the beam. At each position we ensonify the target a known number of times. The number of times the target is detected compared to the number of times the target is ensonified gives a measure of the detection efficiency of the transducer at that point. These measurements have led to a mathematical model that expands the fish-count of a particular transducer to yield a more accurate estimate of fish passage (Mulligan and Kieser, 1996).

The diversion weir and target frame are a key part of our standard aiming procedure in preparation for fish counting. Since migrating salmon are bottom and bank oriented at our site, we try to aim the beam as close to the river bottom as possible. We also aim the beam parallel to the diversion weir (and hence, perpendicular to the river flow) so that fish passing by the end of the weir travel through the beam perpendicular to the beam axis. To simplify this aiming procedure we attach a target to the target frame and lower the frame into position at the end of the weir. We then rotate the transducer until the target appears in the centre of the beam. This establishes the beam axis parallel to the diversion weir. Next, we lower the target to the bottom of the target frame and lower the beam until the target just appears on the oscilloscope; aiming lower will run the beam into the river bottom and reduce the maximum range. Thus, we can quickly and reapeatably configure the acoustic beam parallel to the diversion weir and close to the river bottom.

For dual-beam and single beam systems, use of the target frame to map an effective beam width has merit. A target placed in the frame would be located in the beam centre when it appears at peak amplitude on the oscilloscope. Movement of the target through the beam could be directly measured off the frame and corresponding amplitudes recorded from the oscilloscope. Similar to the split-beam system, minimum distance from the bottom could also be measured by positioning the target at the bottom of the frame and lowering the beam until the target just appears on the oscilloscope.

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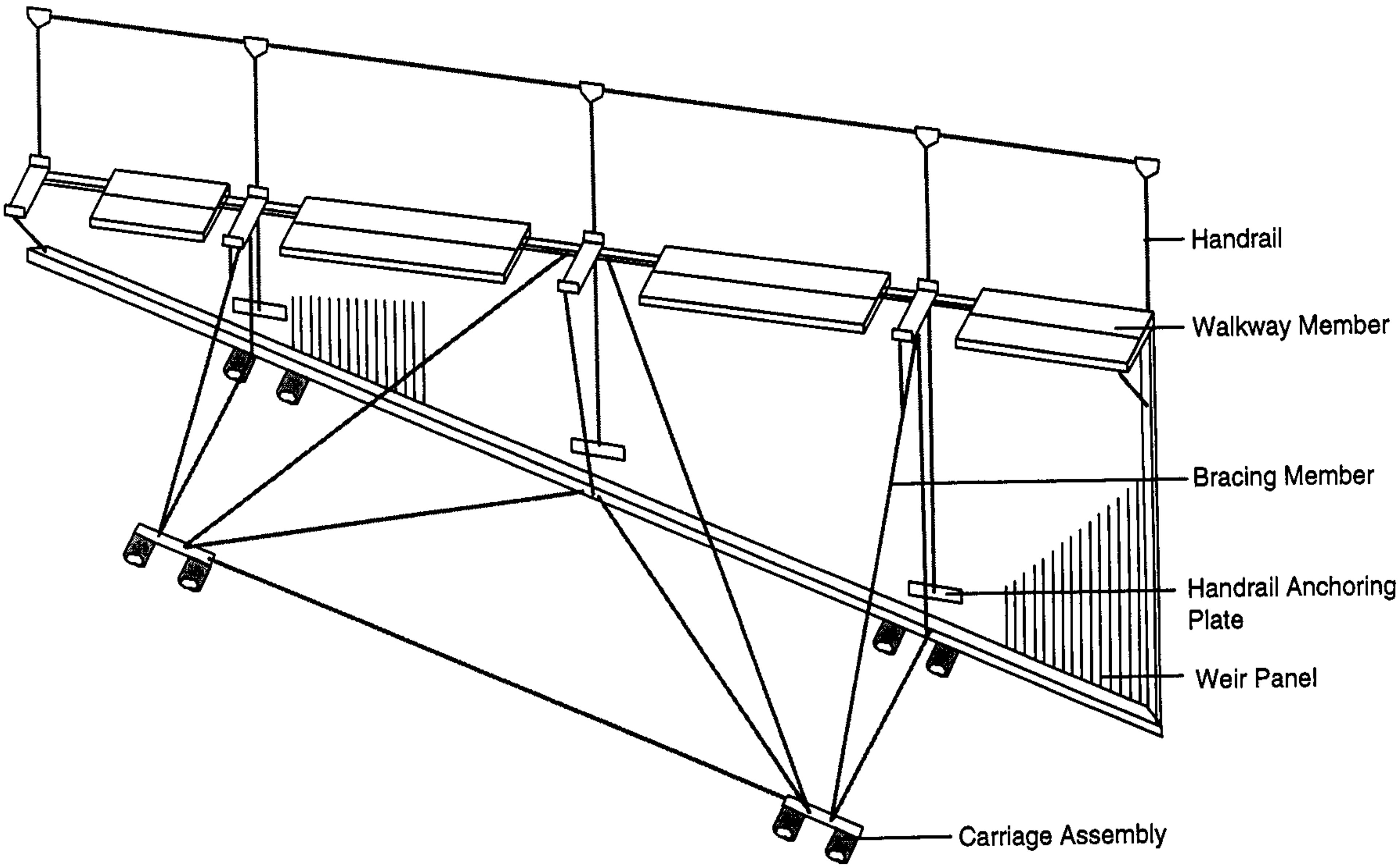

Fig. 1: Schematic of diversion weir showing weir panel, bracing, carriage assembly, and walkway with handrail.

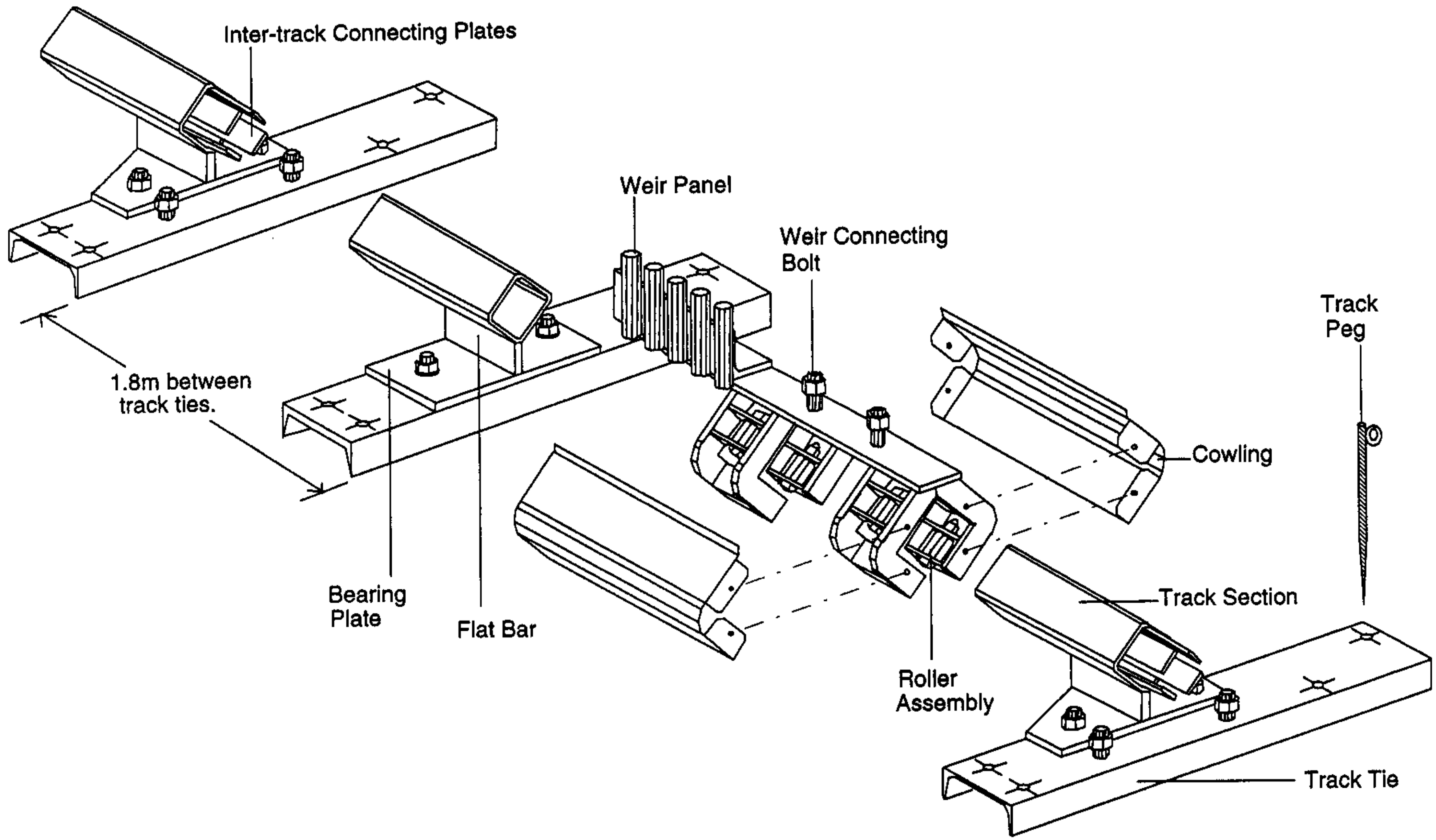

Fig. 2: Exploded diagram of carriage assembly and track section.

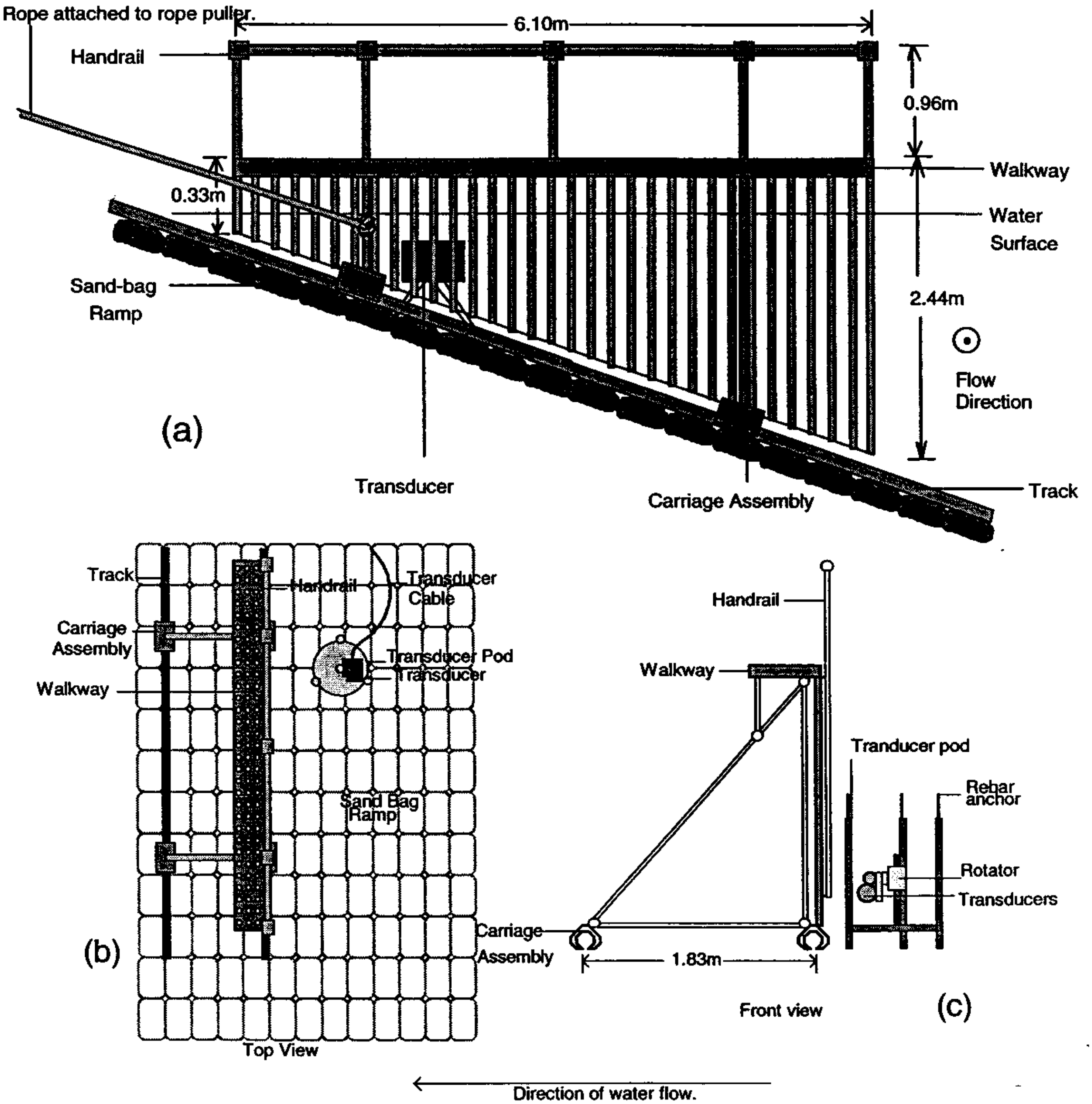

Fig. 3: Side (a), top (b), and front (c) schematic views of the diversion weir and track.

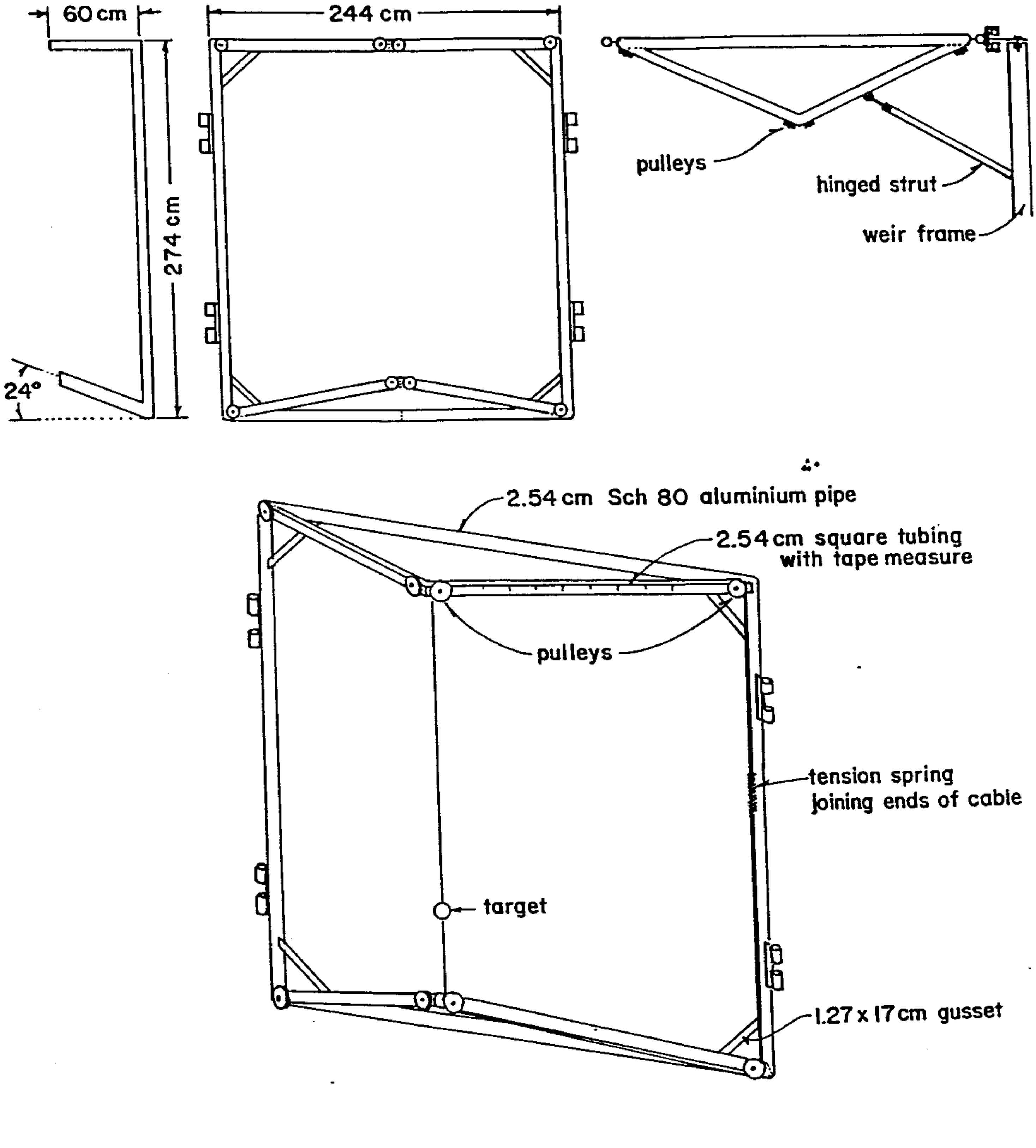

Fig. 4: Side, front, top, and three-dimensional views of the target frame.

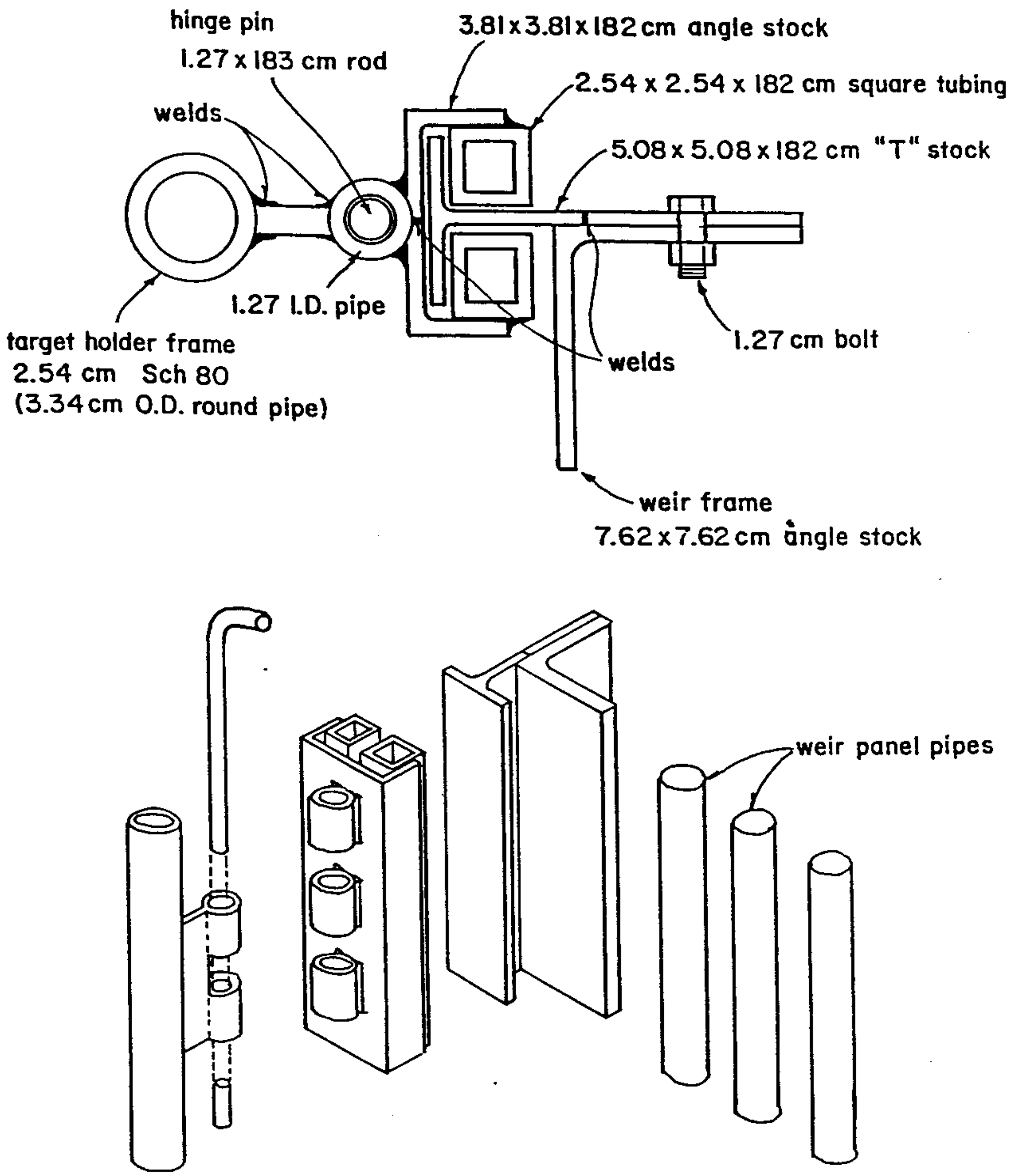

Fig. 5: Hinge and slide receiver connecting the target frame to the weir.

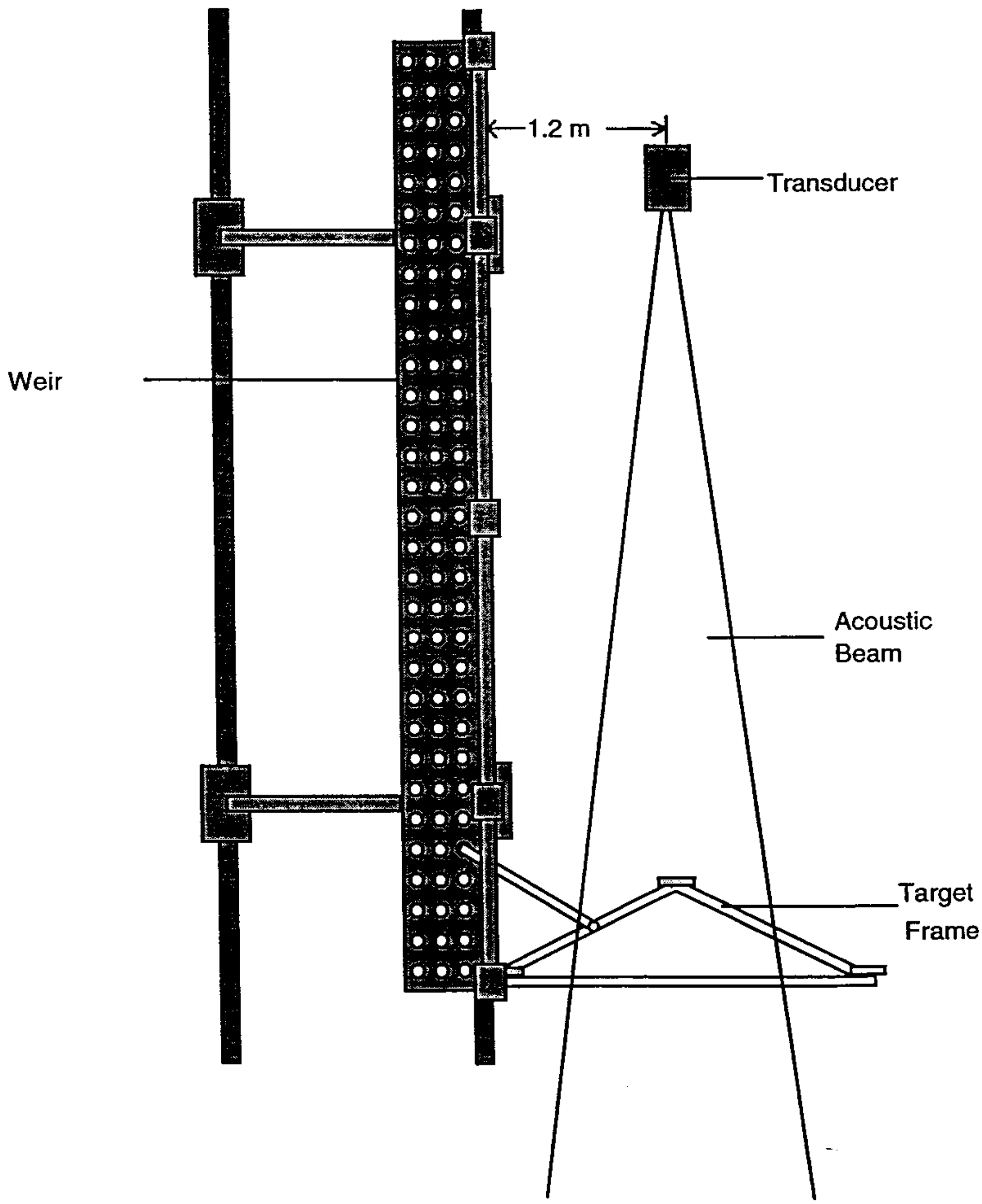

Fig. 6: Top-down view of the weir with target frame attached. This is the configuration used during standard target calibrations.