WD 43-B

State of Idaho
DEPARTMENT OF WATER RESOURCES
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June 21, 1999

Jeff Sessions
Round Mountain Ranch
HC 72, Box 2346
Malta, ID 83342

Harold and Ray Jones
Sublette Rt.
Malta, ID 83342

Re: Weirs in East Ditch from Idaho Weir

Dear Gentlemen,

This letter is a follow up to recent correspondence concerning distribution of Clear Creek rights and flows. One of the orders from the SRBA court last year required that Harold and Ray Jones install a measuring device on their lateral from the 'East Ditch' running from the Idaho weir. For reasons unknown, the court did not include this requirement for the Round Mountain Ranch lateral in the same order. However, Round Mountain Ranch did install a weir on this lateral earlier this year. This latter installation is an appropriate action considering the various court orders and distribution problems on the East Ditch. Harold and Ray Jones also installed a weir in their lateral either last year or earlier this year. A weir is also located at the head of the East Ditch near the Idaho weir. The department appreciates the efforts of the users on the ditch but has concerns about the construction and installation of all three weirs.

Weir in Jones Lateral:
Department staff inspected this weir earlier this spring. The following installation problems were identified:

- Side slopes of Cippolletti weir appear flatter than the required 1 to 4 slope.
- Weir is not perpendicular to ditch flow path and leaned upstream
- Weir not anchored or secured properly, held in place only by cobbles, poor seal along bottom of weir which would allow water to leak through the weir and cause possible wash out of the weir

Weir in Round Mountain Lateral:

- Weir crest should be raised so that the top edge of the metal crest blade sits 2-1/2 inches above the concrete notch.
- Maintain or remove sediment in approach channel to assure that weir crest is no less than one foot above the bottom of the approach channel. Although not standard, this distance may be somewhat less than one foot, but should at least be one-half foot or greater.

Weir at head of the East Ditch:

- Weir crest is set too low to the bottom of the approach channel and should be raised significantly. Weir crest should be no less than one foot above the bottom of the approach channel. Although not standard, this distance may be somewhat less than one-foot, but should at least be one-half foot or greater.
- Weir blade poorly attached to concrete bulkhead. Observed gaps between weir plate and concrete where water could flow around, instead of over the weir plate.
- Potential for water to around ends of concrete bulkhead unless ends are properly sealed and weir pool properly cleaned or maintained.

Enclosed with this letter are some guidelines for the proper installation and maintenance of standard weirs. Please take the time to study these guidelines to assure proper installation and maintenance of your weirs for the remainder of this year and in the future. The department asks that you immediately address the problems identified above by repairing or maintaining the weirs as recommended in this letter and in accordance with standard published guidelines.

Please contact me directly at 327-7864 or the regional office if you have questions concerning this matter or need further assistance.

Sincerely,

Tim Luke

Tim Luke

Cc: Dave Sundberg, Watermaster
Allen Merritt, IDWR Southern Region Mgr.

Enclosure

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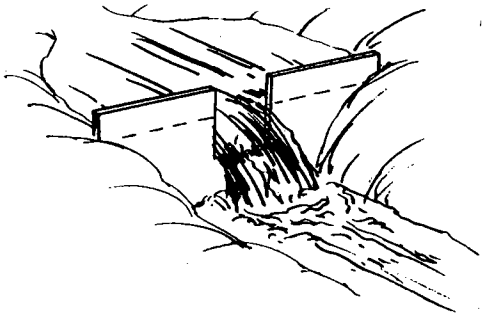
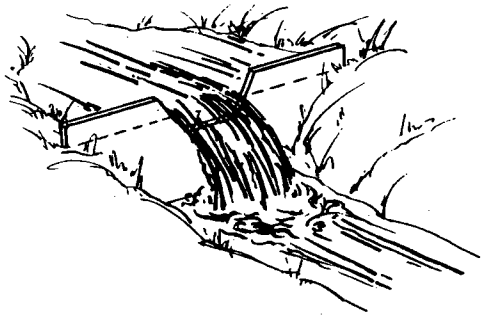
Water is conveyed in both open channels and closed conduits. This bulletin will consider some of the standard water measuring devices designed to operate under open and closed flow conditions.

OPEN FLOW

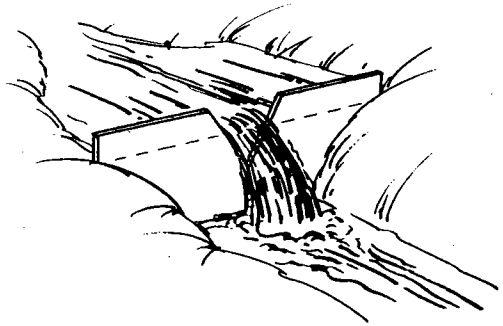
Idaho has many miles of open canals and ditches. On-farm conveyance and distribution systems equipped with measuring devices will improve water distribution and make the irrigation job much easier.



Rectangular weir



Cipolletti weir



V-notch weir

Fig. I. Three types of weirs used in Idaho.

Weirs

A weir is an over-pour notch of fixed dimensions in a vertical bulkhead or head wall through which water may flow. When properly constructed, installed and maintained, it provides a simple and accurate means of measuring water. Weirs are easy to construct and accurate if dimensions are followed carefully. They will handle floating trash and not clog easily.

Every water-measuring device has a set of standard operating conditions that must be met if it is to be accurate. If these conditions cannot be met at a given site, another measuring device should be used. A weir requires approximately a 6-inch drop between the upstream and downstream water surfaces. This loss in head is often not available in ditches with flat grades. The water must approach the weir crest very slowly. This condition is achieved by backing the water up in a weir pond with a bulkhead or head wall.

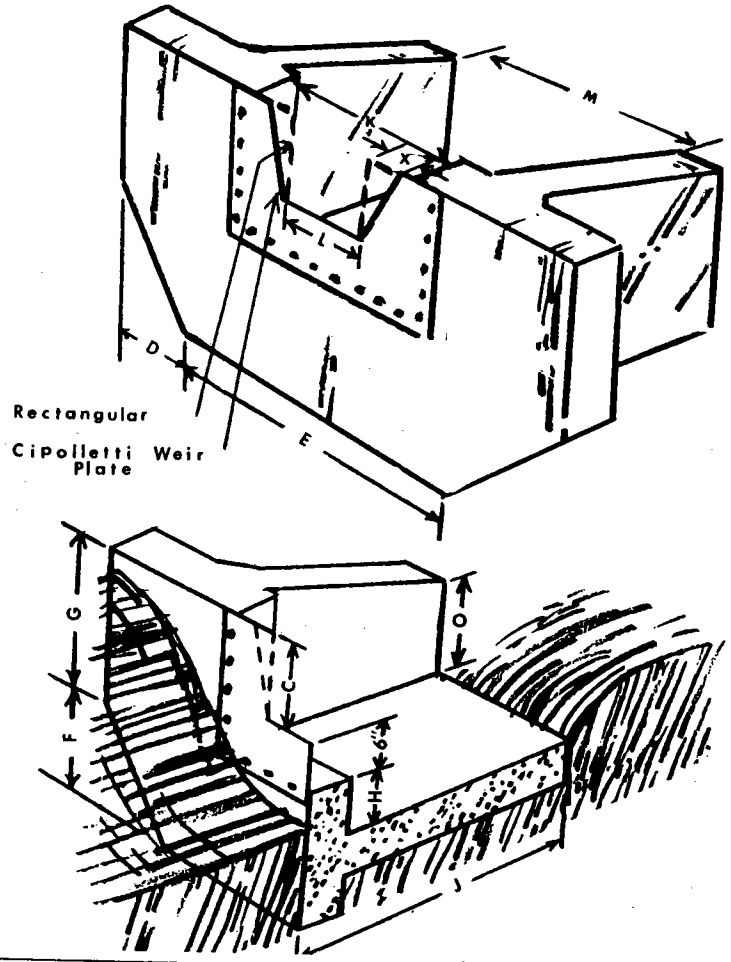
If the water is carrying silt it may settle out and fill the weir pond. This causes the approach velocity of the water to increase and the device becomes inaccurate. Grass and weeds thrive in the slow water and the weir pond requires maintenance to keep it free of silt and weeds.

Commonly used weirs, classified by the shape of the notch, are the rectangular weir, the Cipolletti weir, and the V-notch weir as illustrated in Fig. 1.

How to Install a Weir

A weir can perform accurately only if correctly constructed, installed and used. The following standard conditions must be followed:

1. Set the weir in a channel that is straight for a distance upstream from the weir of at least 10 times the weir crest length.
2. Place the weir at right angles to the direction of flow, and vertical.
3. The water approaching the weir should be free from eddies and flow slower than one-half foot per second. A weir pond can be created by the way the structure is built. The height of the crest above the bottom of the ditch should be at least twice the maximum head or depth of water flowing over the crest. The distance from the side of the weir notch to the side of the channel should be at least twice the maximum weir head. This is called a contracted weir. A bulkhead of the above proportions is used with a metal weir plate fastened to it.
4. Avoid backing the water up on the downstream side of the weir. Water must flow freely below the device, leaving an air space under the over-falling sheet of water. A concrete or rock apron should be used to prevent washing below the structure.
5. The weir plate containing the notch is usually made of steel plate no thicker than 1/8 inch. It must have exact dimensions and its edges must be rigid, straight and sharp on the upstream face. The notch should be beveled at 45 degrees on the downstream side. Avoid knife edges as they are difficult to maintain. The weir crest should be level and very accurate in length.
6. Select the crest size so the minimum head to be measured exceeds 2 inches and the maximum head is not greater than one-third the length of the weir.



Crest length L ft.	Recommended range of measurement in C.f.s. Rectangular	Cipolletti	C=H ft-in	D ft-in	E ft-in	F ft-in	G ft-in	J ft-in	K ft-in	M ft-in	N ft-in	O ft-in	X in
						For Rectangular and Cipolletti Weirs							
1.0	.2 to .6	.2 to .6	8	0	5-8	0	2-7	3	2	2-6	10	1-4	2
1.5	.3 to 1.7	.3 to 1.8	1	1-4	4-6	1-4	2	3-6	2-6	3	10	1-4	3
2.0	.4 to 3.5	.4 to 3.7	1-2	2	5	2	2	4	3	3-6	1	1-6	3½
3.0*	.6 to 9.5	.6 to 10.0	1-6	2-6	7	2-6	2-6	4-6	4-4	5	1-6	2	4½
4.0*	.8 to 19.5	.9 to 20.7	2	3-10	8-4	3-10	2-10	5	5-6	6	2	2-6	6
						For 90° V-Notch Weirs							
2.0	.02 to 1.5		1	1-6	5	1-6	2-8	3-6	2-6	3	10	1-4	
3.0*	.02 to 4.0		1-6	2-2	6-2	2-2	3-4	4	3-6	4	1	1-6	

*Use 6" x 6" No. 12 wire mesh reinforcing or equivalent.

Fig. 2. Dimensions and capacities for Rectangular, Cipolletti and 90-degree V-notch weirs.

How to Measure

The water surface as it flows over the crest is drawn down as velocity increases. For this reason any measurement at or on the crest is not as accurate as the methods described below.

Drive a 2 x 2-inch flat-topped stake in the ground in the weir pool upstream from the crest a distance of 4 times the maximum head. Place the stake to one side in still water out of the way but readily accessible for taking readings. Use a carpenter's level or an engineer's level to set the top of the stake at the same height as the crest of the weir. The depth of flow is measured from the top of the stake to the surface of the water above it. In Idaho, frost will probably heave the stake out of place so that it would have to be re-set and maintained annually to keep the top at the same level as the weir crest.

An observation well (equipped with a staff guage) next to the weir head wall and fed by a pipe from the weir pond will refine the reading.

Water depth may be measured on a bulkhead wide enough so the gauge can be attached to it in smooth water and be unaffected by the drawdown over the crest. The gauge should be at least 1 to 1½ feet away from the side of the notch. Place the zero on the staff gauge at the same height as the crest.

A **rectangular weir** is the simplest to construct. Its crest is horizontal and its sides perpendicular. Table 3 gives the discharges over various widths of rectangular weirs with complete contractions.

The **Cipolletti weir** (named after its inventor, Cesare Cipolletti, an Italian engineer) is used most in Idaho because it will measure slightly more water than a rectangular weir with the same crest length. It is more difficult to construct. The sides diverge outwardly at a 1 to 4 slope (1 inch horizontally to 4 inches vertically). The discharges for various widths of Cipolletti weirs with contractions are shown in Table 4.

The **V-notch weir** is designed to handle small flows accurately. A 90-degree angle or V-notch can be laid out very easily using a carpenter's square. Discharge tables for the V-notch with complete contractions are shown in Table 5. Construction details and dimensions for the weirs mentioned above are illustrated in Fig. 2.

Rectangular Submerged Orifice

A rectangular submerged orifice is a sharp-edged rectangular opening in a vertical bulkhead placed in a stream perpendicular to the direction of flow, having the upstream and downstream water surface above the orifice as shown in Fig. 3. The cross-sectional area of the orifice is small in relation to the stream cross-section. These conditions provide complete contraction of stream flow and the approach velocity of the water becomes negligible.

This device is used on relatively flat ditches where fall is not adequate for a weir. It is simple, easy to construct and accurate. Water should be free from floating trash as it will clog very easily.

submerged weirs as previously defined; also, the rectangular ones may be classed as either contracted or suppressed, as described earlier in this section. In this connection, the common usage of the term "suppressed" applies to a rectangular weir which has its sides coincident with the sides of the rectangular channel. Other types of suppressed weirs are not commonly used and therefore are not discussed here.

8. Types of Standard Weirs.—The types of weirs commonly used by the Bureau of Reclamation for measuring irrigation water are:

Sharp-crested contracted rectangular weirs.
Sharp-crested suppressed rectangular weirs.
Sharp-crested and sharp-sided Cipolletti weirs.
Sharp-sided 90° V-notch weirs.

The following designations are also used for these four types of weirs and will generally be used in this manual:

The standard contracted rectangular weir.
The standard suppressed rectangular weir.
The standard Cipolletti weir.
The standard 90° V-notch weir.

Less commonly used types of weirs are discussed later in the chapter. Rectangular, trapezoidal, and V-notch weirs in settings where contractions are not complete are not classed as standard weirs, and discharge computations must be made individually for them.

Because of greater accuracy, it is the intention of the Bureau to use weirs without submergence, although there may be occasions where it will be necessary to permit submergence for short periods of time.

9. Setting Standard Weirs.—(a) *Standard Contracted Rectangular Weir.*—A standard contracted rectangular weir has its crest and sides so far removed, respectively, from the bottom and sides of the weir box or channel in which it is set, that full contraction is developed. This contraction is approximately the maximum contraction that would occur with the crest and sides of the weir at infinite distances from the channel boundaries.

Extensive experiments on weirs and long experience with their use dictate that the following conditions are necessary for accurate measurement of flow with the standard contracted rectangular weir:

(1) The upstream face of the bulkhead should be smooth and in a vertical plane perpendicular to the axis of the channel.

(2) The upstream face of the weir plate should be smooth, straight, and flush with the upstream face of the bulkhead.

(3) The entire crest should be a level, plane surface which forms a sharp, right-angled edge where it intersects the upstream face. The thickness of the crest, measured in the direction of flow, should be between 0.03 and 0.08 inch (about 1 to 2 mm). Both side edges of rectangular weirs should be truly vertical and of the same thickness as the crest.

(4) The upstream corners of the notch must be sharp. They should be machined or filed perpendicular to the upstream face, free of burrs or scratches, and not smoothed off with abrasive cloth or paper. Knife edges should be avoided because they are difficult to maintain.

(5) The downstream edges of the notch should be relieved by chamfering if the plate is thicker than the prescribed crest width. This chamfer should be at an angle of 45° or more to the surface of the crest.

(6) The distance of the crest from the bottom of the approach channel (weir pool) should preferably be not less than twice the depth of water above the crest and in no case less than 1 foot.

(7) The distance from the sides of the weir to the sides of the approach channel should preferably be no less than twice the depth of water above the crest and never less than 1 foot.

(8) The overflow sheet (nappe) should touch only the upstream edges of the crest and sides.

(9) Maximum downstream pool level should be 0.2 foot below crest elevation.

(10) The measurement of head on the weir should be taken as the difference in elevation between the crest and the water surface at a point upstream from the weir a distance of four times the maximum head on the crest.

(11) The cross-sectional area of the approach channel should be at least 8 times that of the overflow sheet at the crest for a distance upstream from 15 to 20 times the depth of the sheet.

(12) If the weir pool is smaller than defined by the above criteria, the velocity of approach may be too high and the staff gage reading too low. The head should be corrected by increasing it as explained in sections 22 and 23.

(b) *Standard Suppressed Rectangular Weir.*—A standard suppresed rectangular weir has its crest, consisting of a thin plate, so far removed from the bottom of the approach channel that full crest contraction is developed. The sides are coincident with the sides of the approach channel; therefore,

no lateral contraction of water passing through the weir is possible.

Conditions for accuracy of measurement for this type of weir are identical with those of the contracted rectangular weir, except those relating to side contraction. In the suppressed weir the sides of the approach channel should be coincident with the sides of the weir, and should extend downstream beyond the crest to prevent lateral expansion of the nappe. A suppressed weir in a flume drop is illustrated in figure 5.

Special care must be taken with suppressed weirs to secure proper aeration beneath the overflowing sheet at the crest. This is usually accomplished by placing vents on both sides of the weir box under the nappe (fig. 3).

(c) *Standard Cipolletti (Trapezoidal) Weir.*—A standard Cipolletti weir is trapezoidal in shape (fig. 6). Its crest and sides, which are of thin plate, are placed far enough from the bottom and sides of the approach channel so that full contraction of the nappe occurs. The sides incline outwardly at a slope of 1 horizontal to 4 vertical.

The Cipolletti weir is a contracted weir, and should be installed accordingly. However, its discharge occurs essentially as though its end contractions were suppressed because the contractions are compensated by making the sides of the weir slope outward.

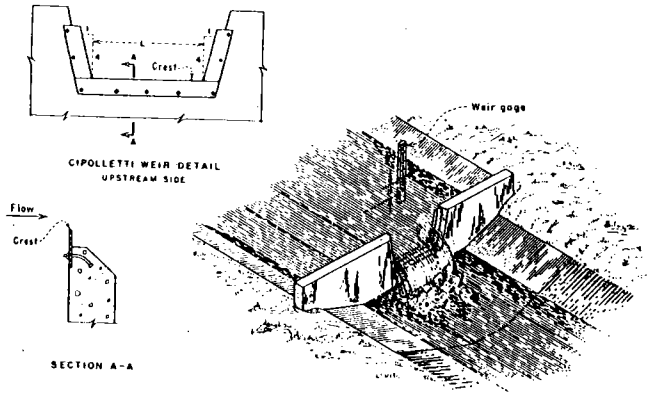


Figure 6.—Cipolletti weir in a permanent bulkhead discharging under free-flow conditions. 103-D-859.

All conditions for accuracy stated for the standard contracted rectangular weir apply to the Cipolletti weir. The height of the weir crest above the bottom of the approach channel should be at least twice the head over the crest, and the distances from the sides of the notch to the sides of the channel should also be at least twice the head. The weir should not be used for heads less than about 0.2 foot, nor for heads greater than one-third the crest length. A Cipolletti weir is illustrated in figure 7.

(d) *Standard 90° V-Notch Weir.*—The triangular or V-notch thin-plate weir is an accurate flow measuring device particularly suited for small flows. The V-notch usually used by the Bureau is the 90° V-notch shown in figure 2.

The crest of the standard 90° V-notch weir consists of a thin plate, the sides of the notch being inclined 45° from the vertical. This weir operates as a contracted weir and all conditions for accuracy stated for the standard contracted rectangular weir apply. The minimum distances of the sides of the weir from the channel banks should be at least twice the head on the weir, and should be measured from the intersection points of the maximum water surface with the edges of the

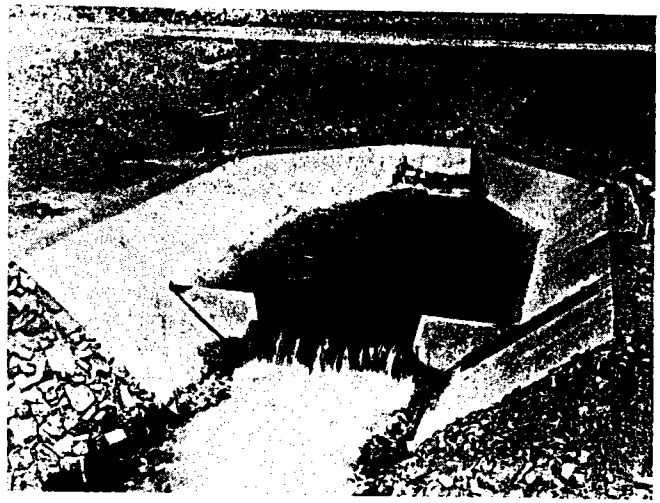


Figure 7.—Cipolletti weir with a well-type head-measuring station. PX-D-53011.

weir. The minimum distance from the crest to the pool bottom should be at least twice the head on the weir, and should be measured from the point of the notch to the channel floor.

Because the V-notch weir has no crest length, the head required for a small flow through it is greater than that required with the other types of weirs. This is an advantage for small discharges in that the nappe will spring free of the crest, whereas it would cling to the crest of another type of weir and make the measurement worthless. Although Cipolletti and rectangular weirs in the order of 6 inches in crest length are sometimes used for measuring small flows, they are not as accurate or as sensitive as the V-notch weir for such flows and are not recommended where the V-notch weir can be used.

10. Selection of Weirs.—Each of the weirs used by the Bureau of Reclamation has characteristics that fit it for particular operating conditions. In general, for best accuracy, a rectangular suppressed weir or a 90° V-notch weir should be used. Cipolletti weirs and contracted rectangular weirs have end contractions and have not been investigated experimentally as thoroughly as the suppressed rectangular and V-notch weirs. They are, however, very useful weirs for many applications.

Usually the range of flows to be measured by a weir can be fairly well estimated in advance. With this range in mind, the following points should be considered:

(1) The minimum head should be at least 0.2 foot to prevent the nappe from clinging to the crest, and because at smaller depths it is difficult to get sufficiently accurate gage readings to calculate reliable flow quantities.

(2) The length of rectangular and Cipolletti weirs should be at least three times the head.

(3) The 90° V-notch weir is the best type for measuring discharges less than 1 second-foot. It is as accurate as the other types for flows from 1 to 10 second-feet. Thus it is well suited for discharges up to and a little beyond 10 second-feet if sufficient head is available.

(4) The crests, if possible, should be placed high enough so the water flowing over them will fall freely, leaving an airspace under and around the jets. If submergence is permitted, special computations and reduced flow measuring accuracy may be expected.

11. Construction and Installation of Weirs.—As a temporary expedient in making approximate measurements of small flows in earth channels, lined tunnels, etc., a portable weir may be used. For earth channels the weir may be made from a piece of stiff sheet metal cut approximately in the shape of the cross section of the channel but somewhat larger, and having a carefully cut weir notch in the top edge. To set this weir, the metal plate is forced firmly into the soft bottom and sides of the channel, normal to the direction of flow, and the crest is adjusted to a level position by tapping down the higher side.

For measurements in lined tunnels, or for making measurements of small discharges in ditches, a weir plate may be installed in a wooden or other bulkhead that has been sandbagged and sealed in place. The opening for the weir notch should be cut about 3 inches longer than the crest length to allow for insertion of angle irons, metal strips, or a plate to form the sharp crest and sides of the weir and to insure that the nappe will spring clear of the bulkhead. Some approximate measurements have been made successfully with a combined weir and canvas dam. The weir structure is used as the upper edge on which to fasten the canvas, and the canvas becomes a dam when held in place across the canal section by piling earth on the lower edge.

These simple bulkheads are not sufficiently stable for permanent installations. To overcome this difficulty, the bulkhead may be built within and firmly fastened to a wooden or concrete weir box similar to that shown in figure 8. When installed in earth channels the weir box should extend downstream from the weir crest to still the water before it passes back into the channel below. The floor of the downstream portion of the box may be slightly depressed to form a stilling pool. In the special case of the standard suppressed rectangular weir, the sides of the downstream portion of the weir box should be coincident with the edges of the overflow sheet. For the rectangular contracted weir, the Cipolletti weir, and the V-notch weir, the sides of the boxes downstream from the weirs should be set outward from the edges of the weir notch.

In all suppressed weirs, a pipe or other means must be provided to admit air to the underside of the nappe to assure proper aeration and hence proper contraction of the jet.

Table 5 and figure 8 [1] [1] give the dimensions of weirs best suited for measuring the flow of water from ¼ to 60 second-feet.

[1] Numbers in brackets represent items in the bibliography, sec. 33.