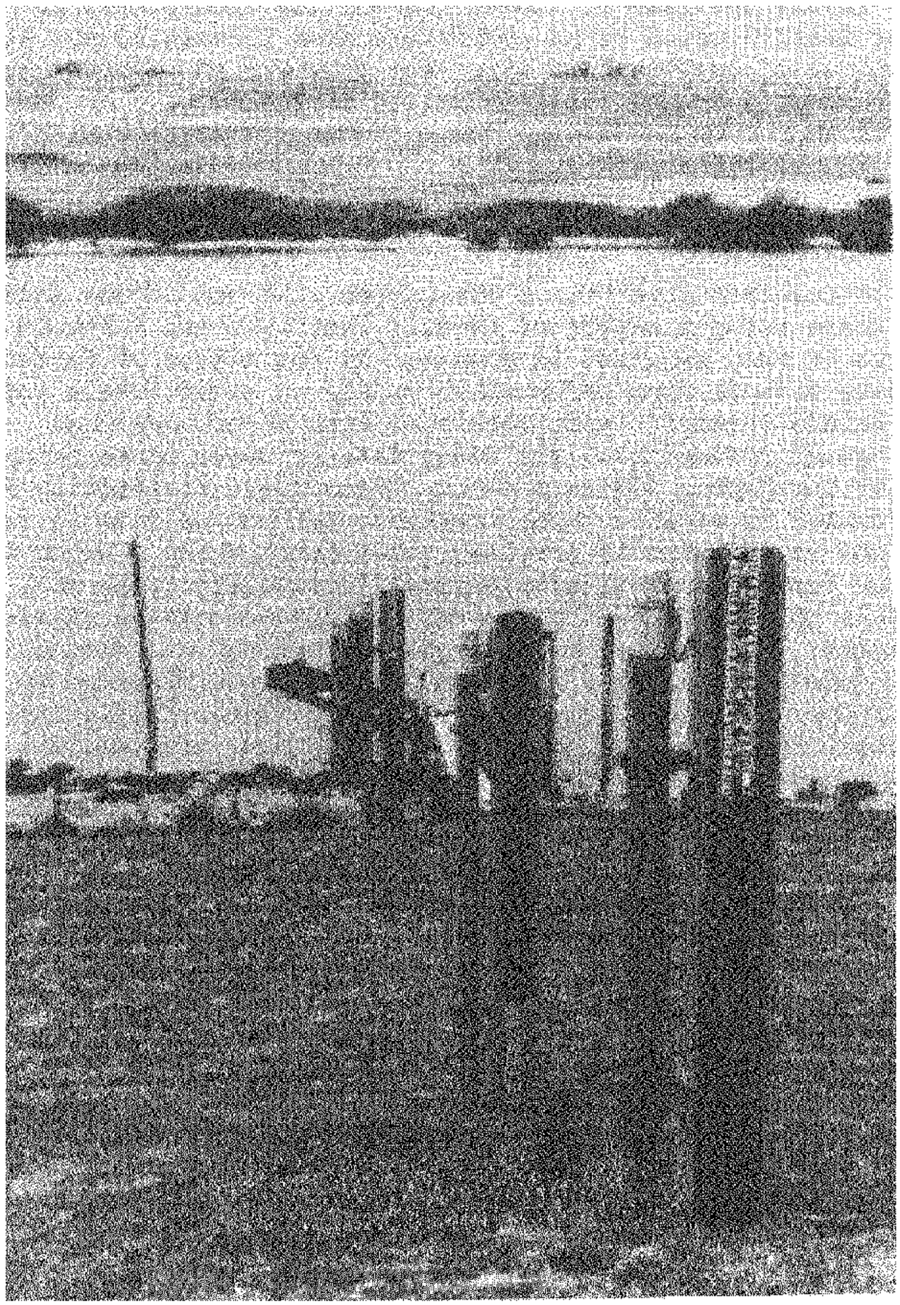

FIG. 3.13 - Differential coloured staff gauges
and reed-switch gauges in Japan
(original in colour)

inside of which are a number of reed switches mounted in a vertical line at small intervals of height. Water level of satisfactory resolution for flood conditions is indicated by the number of switched on reed switches caused by their inundation. Level gauges are used in tidal and non-tidal waters. In rivers, conversion of monitored water level (or stage) to values of river discharge is executed through stage-discharge relationships established by using one of several well known flow gauging methods.

Rainfall

3.3.1.2 Rainfall gauges are of the recording or non-recording type. Both are useful in general data acquisition but recording raingauges are particularly useful in flood forecasting because of their adaptability to automatic data transmission. A network of raingauges is usually required on catchments to monitor over-all rainfall and its distribution. Placing of the gauges in the river basin and the number required can be determined in an objective manner but for flood forecasting purposes in particular this is still largely a process involving individual insight and experience.

Snow

3.3.1.3 Snow is very difficult to measure as it falls; instruments akin to raingauges are available but their catch of snow is not usually efficient due mainly to wind turbulence around the gauges. The conservative nature of snow makes it amenable to measurement on the ground in the form of a snowpack. This is most commonly done using snow core samplers in snow surveys carried out at periodic intervals. Snow platforms, pressure pillows, and radio isotope gauges are also used, but suffer from the disadvantage that they measure groundsnow at one point only which is not generally satisfactory due to the heterogeneous nature of snow depth. Modern research indicates the viability of using the measurement of natural gamma radiation from the Earth through the snowpack as a measure of the water equivalent. This is operational in the U.S.S.R. and is an advantage when carried out from aircraft since individual measurements represent average water equivalents of areal units.

Radar

3.3.1.4 Radar deserves a very special mention in the context of flood forecasting. For many years the ability of radar to identify and track storms has been well known. This ability has also given radar the importance of being able to detect the areal extent of storms and where in a region much catchment rain is falling. Radars are especially useful in helping to locate very localized intense storms, not easily detectable by normal raingauges networks, and to track tropical cyclones to promote qualitative early warnings of potential flood disaster.

A relatively more recent development has been the important application of radar to giving estimates of rainfall intensities. These estimates are based on a simple relationship of the form,

$$R = \left(\frac{r^2}{cA} \cdot P\right)^{\frac{1}{B}}$$

where P is the measured power of radar signal reflected from rain falling with an intensity R at a point of distance r from the radar set. C, A and B are coefficients. The last two coefficients vary between storms and give rise to problems in estimating rainfall intensity accurately. One standard procedure to determine values of A and B for a given storm is to compare values of rainfall intensity measured at one or more reference raingauges at some distance from the radar with the corresponding signals given by the radar. Mean relative accuracy of measurement in current applications is of the order of ± 10 to 20 per cent.

For the reasons given, intensive application of weather radar to storm warning systems is now used in various countries including Japan, Malaysia, Philippines, Korea, U.S.A., U.S.S.R., Hungary and Great Britain. Advantages of weather radar, which can also detect and measure snowfall but not yet efficiently, are weighed against the high cost of installation and maintenance, and the special equipment and skill required in processing information. Such high cost, however, is compared with a high cost of a telemetering raingauge network providing an equivalent density of information.

A special advantage of radar, especially when it is utilized in estimating quantities of rainfall intensity, is its speedy ability to display the values it determines. Fig. 3.14 shows an example of such a display superimposed on a schematic plan of catchment and drainage network, (originally in colour). Such a display is of invaluable assistance to a forecaster.

Climate

3.3.1.5 Several climatological factors are effective in river flooding. Wind velocity is a prime cause of coastal and estuarial floodwaters; it is measured with standard anemometric instrumentation. Air temperature, and sometimes solar and atmospheric radiation, are important parameters affecting snowmelt and the potential of ice flows and ice jams. Standard thermometric instrumentation exists for the measurement of temperatures and humidity. Radiometers are also now in general use. Climatological units on which are mounted various climatological sensors are a more recent and very useful innovation. Signals from various sensors are recorded in one unit, often a magnetic tape, and this central receiver lends itself readily to automatic data transmission. Other factors such as wetness of ground are also monitored if required.

The density of information required for climatological parameters is in general not as large nor as localized as it is for precipitation and streamflow. Weather forecasts, for instance, frequently provide reliable information as for example on wind velocity and air temperature, often sufficiently accurate to allow useful and early forecasts of river flooding by wind set up or snowmelt to be made. Synoptic forecasts can also be useful in anticipating an ice-jam hazard as in Hungary. Meteorological monitoring and weather forecasts are very useful elements in predicting river floods. Details of this type of monitoring are given in another volume.

In recent years satellite technology has added a new dimension to data monitoring (page 63). Although remote, sensors on satellites, and particularly normal and infra-red photographic equipment, can measure a number of phenomena,

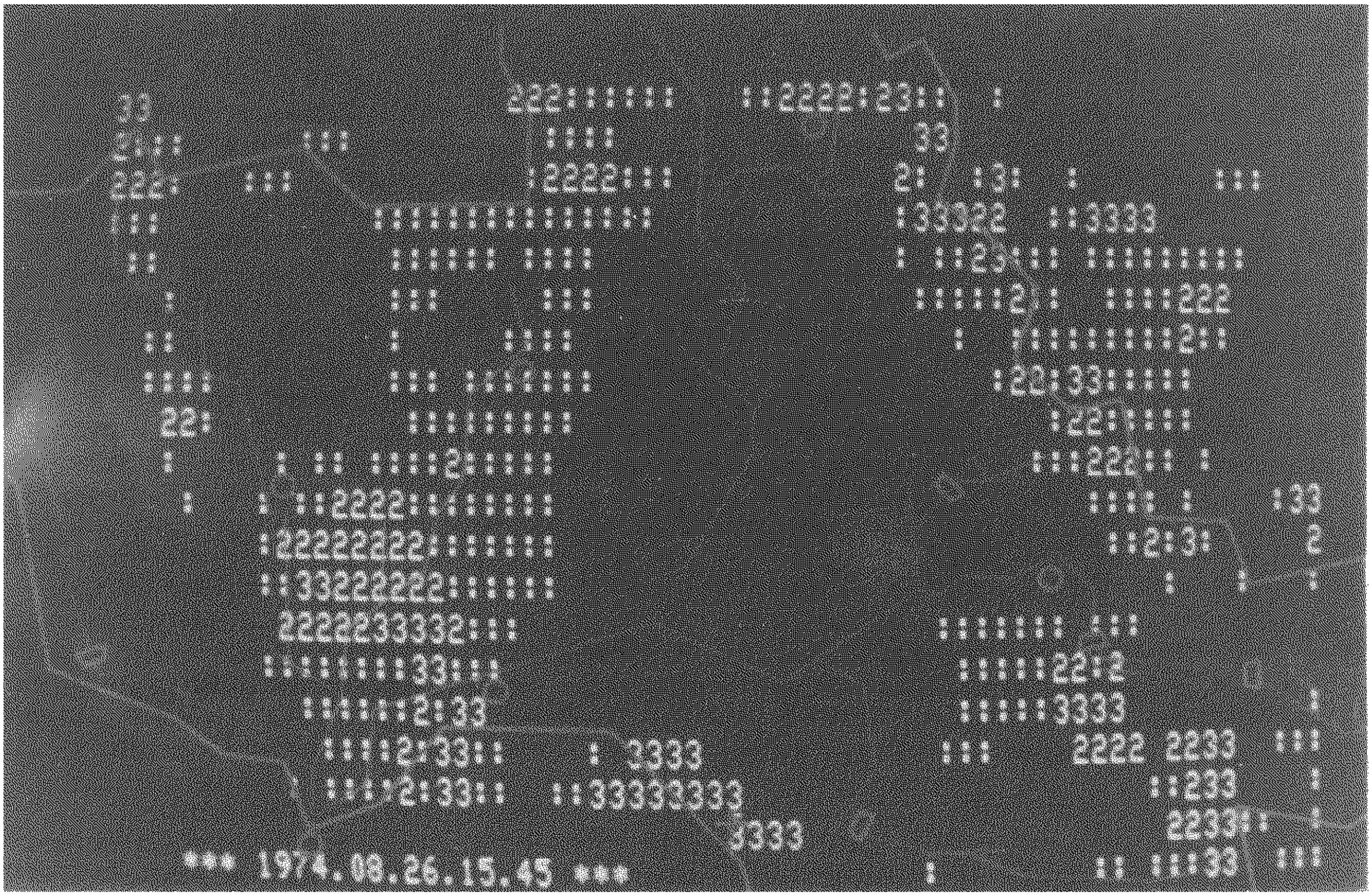

FIG. 3.14 - Character display of rainfall in the Upper Tone river basin by the radar at Mte Akagi. One character corresponds to a 3.25 km x 1.56 km domain

(Space means 0 1 mm/hr rainfall, : means 2 4 mm/hr, 2 means 5 9 mm/hr, and 3 means 10 19 mm/hr)