DISCUSSION ON "INSTRUMENTS AND MEASUREMENTS," AT PITTSBURG, PA., May 8, 1905.

WM. BRADSHAW: One would infer from Mr. Nies' paper that the polyphase meter is an inherently inaccurate instrument. A polyphase meter so constructed that there are no mutual electrical or magnetic influences between the two meter elements, should and does operate just as accurately as the single element of a single-phase meter. This independence of the two meter elements is made permissible by connecting them together mechanically instead of electrically and magnetically. A polyphase meter mechanically connected between the two elements (that is, with two complete meter elements respectively acting upon two discs fixed to the same shaft) is polyphase only in that it may be so connected with polyphase circuits as to measure accurately the power whether the circuits are balanced or unbalanced.

A polyphase meter is not more difficult to calibrate than two single-phase meters. When the "bucking" process is used to bring the two meter elements into step, the error introduced by friction is negligible because the adjustment is made midway between the limits that give motion forward and backward. The total range being about 0.5% of full-load torque, the roughest approximation will give results of sufficient accuracy. If this method is used for setting the meter for zero power-factor, it will give very reliable results on loads of any power-factor.

Either a mechanically or an electrically constructed polyphase meter will be affected to the same degree as the single meter element is affected by varying voltage, frequency, wave form, etc., hence the use of a number of separate single-phase meters in place of a polyphase meter will not insure any greater reliability.

The possibility of using the separate readings of single-phase meters as a check on each other would be very remote, because a polyphase circuit that would be balanced within the limits of a modern service meter would be an ideal condition seldom attained; if it were attained it would be better to connect the two meters in series in one phase.

A polyphase meter with mechanically connected meter elements, and connected with transformers especially designed for use with instruments, will give, when the transformers are not overloaded, far more accurate results than those maintained in Mr. Nies' paper, under any condition of load, voltage, or frequency. It is strongly recommended, when a change is to be made from the readings of a meter, that each meter be installed with a separate series transformer.

Referring to Mr. Cox's remarks on switchboard indicating instruments, good switchboard instruments should have the following requisites: the readings should be accurate within plus or minus 2% under all conditions after being installed.

The instruments should have the maximum length of scale permissible for minimum switchboard space. The scale should be conveniently divided, with open divisions. The instruments should be deadbeat. The ratio of torque per unit weight should be maximum. The total weight of moving elements should be small. They should be but only slightly affected by external fields, changes of temperature, wave-form, frequency, unbalancing of the circuit, and should be accurate on inductive loads. Their mechanical design should be pleasing and substantial.

The testing meter described by Mr. Mowbray has a useful field, but it must be used with discriminating judgment. Such a standard meter should be used to test meters in service to indicate whether or not the service meters need to be removed for recalibration. And the central station using an integrating standard meter for this service should have an accurate and reliable indicating standard for frequently checking the calibration of the standard integrating meter. The best service is obtained from a standard meter when its use is practically continuous, because a meter while standing idle is more liable to get dust in the jewel and develop friction than is a meter that is in continuous operation. The standard meter should be of the same type as the service meter under test; or else the load, voltage, and frequency characteristics of both the standard meter and the service meter under test should be known and compared before the service meter is condemned as being inaccurate. Some types of meters will run fast on less than their normal voltage and frequency, while others will run slow; and consequently a meter might be condemned as being as much as four or five per cent. in error, when in reality it would be within two per cent. of being correct. When a standard integrating meter is used with the precautions given above, it furnishes a reliable, accurate, and rapid method of checking integrating wattmeters while in service.

STEPHEN Q. HAYES: Concerning Mr. Bradshaw's remark that there is no reason why the series and shunt leads, referred to on page 189 of Mr. Nies' paper, should be connected together, I understand that Mr. Nies' idea is to connect one side of all of the series transformers and one side of all of the shunt transformers to a common ground wire. One side of the current coils and one side of the voltage coils of the switchboard instruments would also be connected to a common ground, and the two grounds would be connected together by a single wire.

Referring to Mr. Cox's paper, page 198, relative to the size of indicating instruments to be used on generator and feeder circuits, some engineers advocate the use of instruments of such size that even on a sudden heavy overload there shall be no possibility of the needle swinging to the end of the scale and possibly being bent or broken. The rule of the Westinghouse Company is to supply instruments of such size that they will

take care of 50% overload on the feeder or generator circuits with which they are connected; but for special cases, when required, larger instruments have been furnished to obviate the possibility of damage to the needle due to heavy overloads.

Referring to page 199 of Mr. Cox's paper, relative to the calibration of switchboard instruments, the Westinghouse Company recently made it a practice, whenever requested to do so, to place testing plugs on the switchboard panels, both for the current coils and for the voltage coils of the instruments, so that it is a comparatively simple matter to connect in a portable testing meter in order to calibrate the various instruments.

Too much importance cannot be placed on the last paragraph, on page 200 of Mr. Cox's paper; with polyphase instruments it is of the utmost importance that the connections should be made correctly; it is better to be guided by a diagram of connections than for one not thoroughly familiar with the switchboard instruments to connect up meters in a manner which he supposes will give the same results.