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Fink et al.

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[54] **ROLLER GAP CONTROL**

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Mar. 17, 1971 Germany .... P 21 12 987.7

[52] **U.S. Cl.** **72/35,** 72/21

[51] **Int. Cl.** **B21b 31/34,** B21b 37/08

[58] **Field of Search** .... 72/21, 8, 35; 324/34 TK, 34 PS, 34 D

[56] **References Cited**

UNITED STATES PATENTS

3,358,485 12/1967 DeCaro et al. .... 72/35 X

3,662,576 5/1972 Giriatschek 72/21

Primary Examiner—Milton S. Mehr

Attorney—Walter Becker

[57] **ABSTRACT**

An arrangement for controlling the roller gap, especialy of multi-roller systems, in which the transmitter housing is two sectional and the housing sections are arranged on both sides of the plane through the centers of the working rollers. The primary elements are designed for the direct, e.g., inductive contact-free stroke measurement to ascertain the roller gap and are so connected to the rest of the central device, i.e., the rated-actual-comparitive stage, that the mean value of the two primary elements of one frame side represents the actual value of this frame side.

4 Claims, 11 Drawing Figures

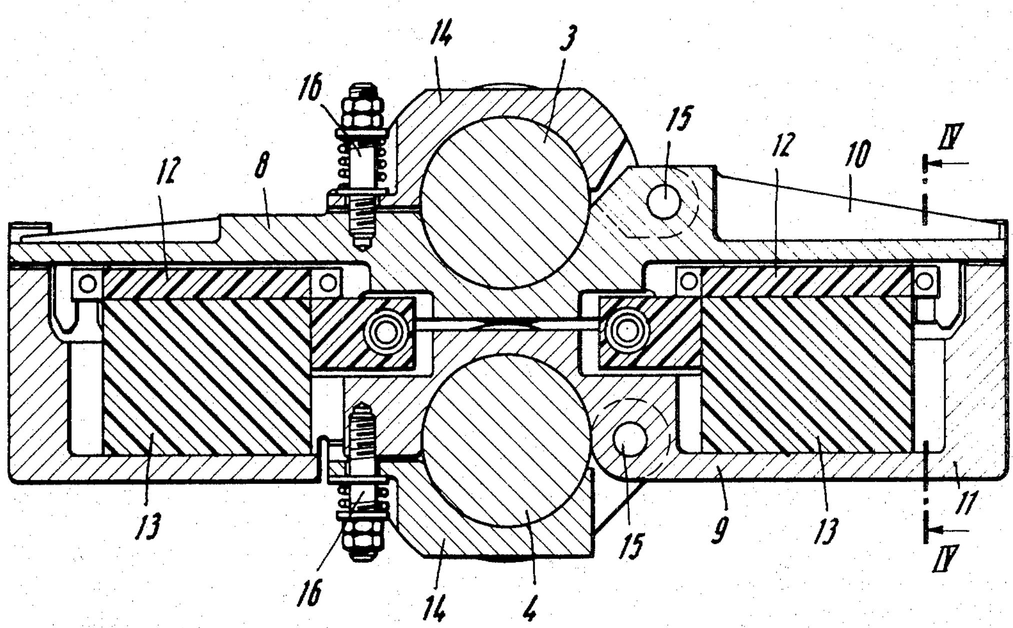


Fig. 1a

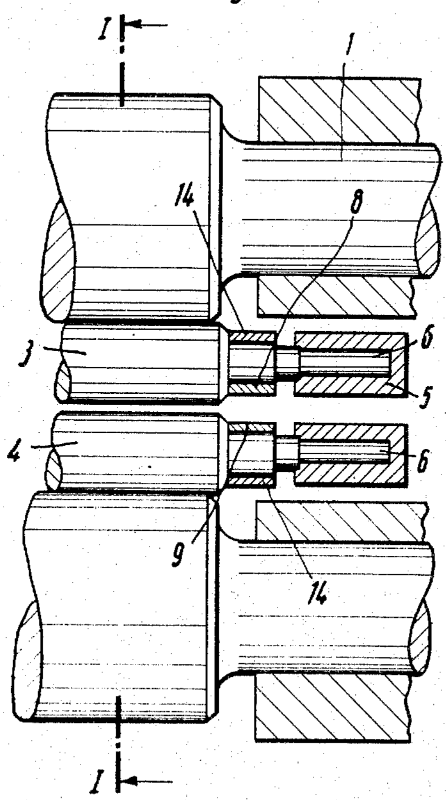


Fig. 1

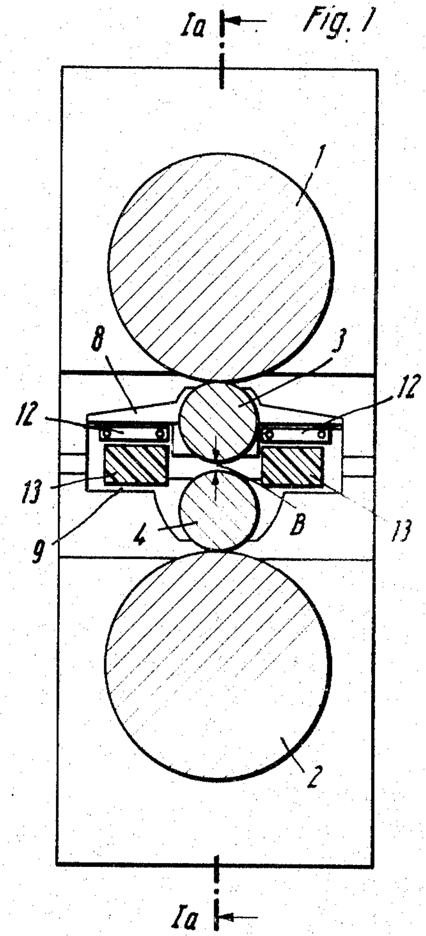


Fig. 1b

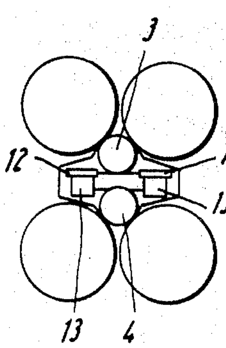


Fig. 1c

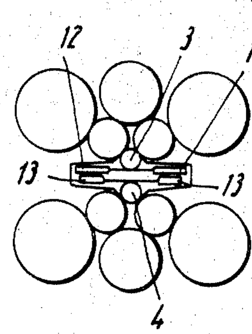


Fig. 4

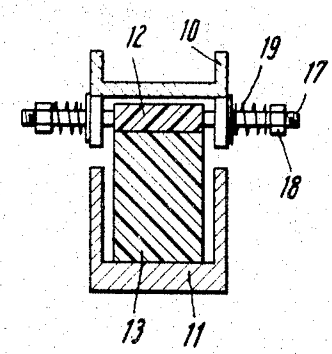
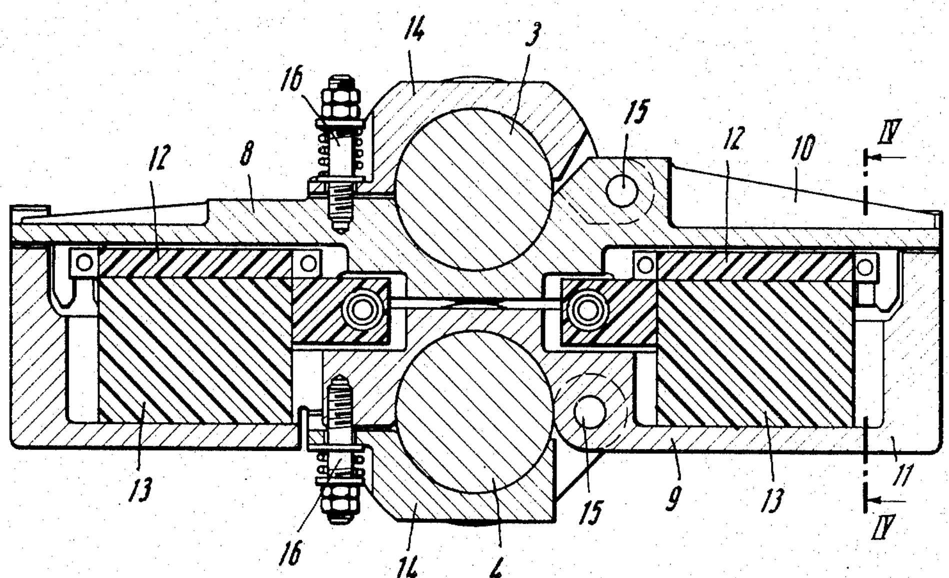


Fig. 3


14
3
16
15
12
8
12
10
IV
IV
13
11
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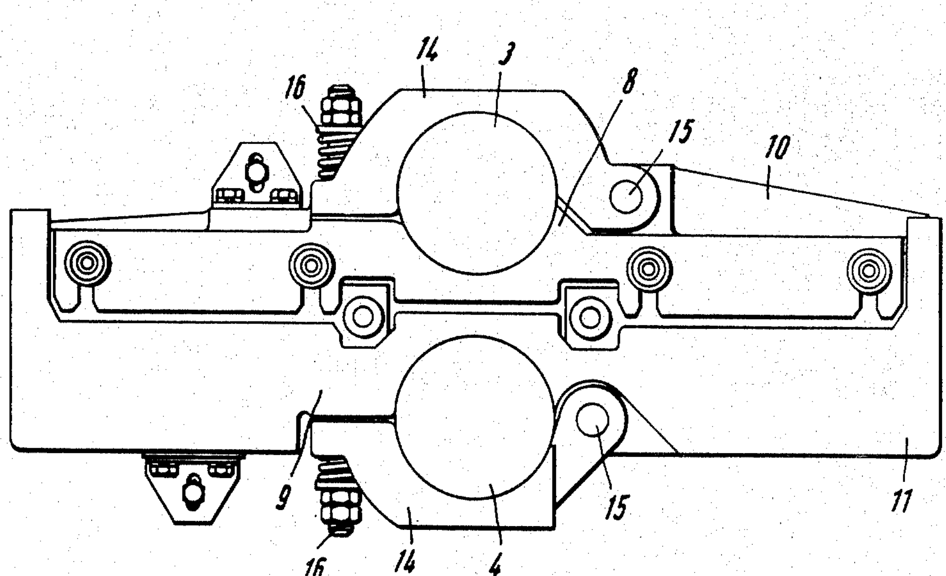
9
13
16
14
4

Fig. 2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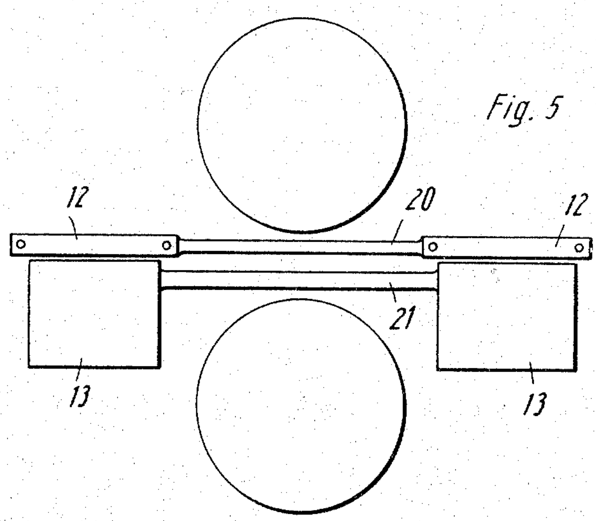

Fig. 5

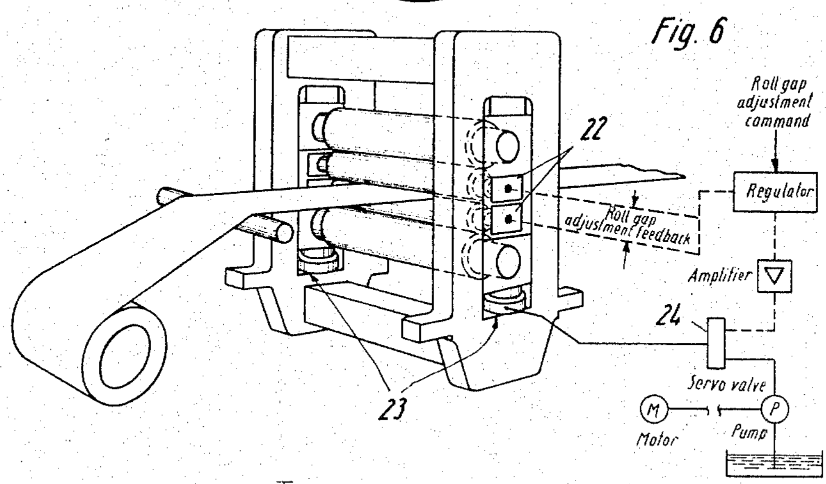

Fig. 6

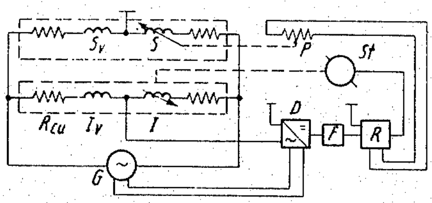

Fig. 7

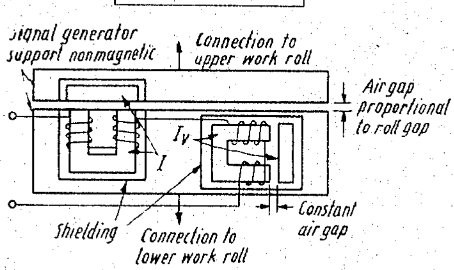

Fig. 8

ROLLER GAP CONTROL

The present invention relates to an arrangement of the primary elements for the control of the roller gap, especially of four high or multiroller rolling mill stands, according to which on each side of the stand and on both roller pivots of the working rollers associated with each other there is provided a transmitter or pickup housing.

With heretofore known devices of the type involved for controlling the roller gap in conformity with the measured value of a direct roller gap measurement, the primary elements are arranged between the roller pivots, which means that on each side of the stand in the plane passing through the roller there is located a primary element. Only roller stands with a certain minimum roller diameter can be equipped with such an arrangement. This is due to the fact that the primary elements require a predetermined structural height. When the difference in diameter of the roller barrel and of the roller pivot of the working rollers is less than this minimum height, the primary elements cannot be mounted, while the difference in diameter in its turn is dependent on the size of the roller diameter.

It is an object of the present invention to provide an arrangement of the general character involved which will overcome the above mentioned drawbacks of heretofore known primary element systems and will make it possible to employ the direct roller gap measurement also in connection with roller stands having small diameters of the working rollers.

This object and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIG. **1** is a transverse section through a four high roller rolling mill stand according to the invention, said section being taken along the line I — I of FIG. **1***a*.

FIG. **1***a* is a longitudinal section through the rolling mill stand of FIG. **1**, said section being taken along the line I*a*—I*a* of FIG. **1**.

FIG. **1***b* diagrammatically illustrates a six high rolling mill stand.

FIG. **1***c* is a diagrammatic representation of a multiroller rolling mill stand according to the invention.

FIGS. **2** and **3** illustrate a portion of FIGS. **1** and **1***a*, but on a larger scale than the latter, and in particular, FIG. **2** is a side view of a transmitter or pickup housing according to the invention, while FIG. **3** is a cross section through the housing of FIG. **2**.

FIG. **4** is a section taken along the line IV — IV of FIG. **3**.

FIG. **5** diagrammatically illustrates centering means between the upper and lower transmitter housing sections.

FIG. **6** shows by way of example a block diagram of a gap-control system for use in connection with a hydraulically controlled strip rolling mill according to the invention.

FIG. **7** illustrates a schematic diagram for an inductive transducer system for use in connection with the present invention.

FIG. **8** shows the mechanical construction of the transducer system of FIG. **7**, said construction being identical for reference and feed back transducers.

According to the present invention, for an arrangement of the above described type, it is suggested that between the installation part and the roller barrel the upper part of the transmitter or pickup housing is in a play-free manner mounted on the roller pivot of the upper roller, whereas the lower part of the transmitter or pickup housing is in a play-free manner mounted or journalled on the roller pivot of the lower roller. The upper as well as the lower part of the transmitter housing is provided with a holding arm which, when seen in rolling direction, protrudes forwardly and with a holding arm, which with regard to the rolling direction, protrudes rearwardly. Between each two holding arms associated with each other there is provided one primary element each. The two-sectional design of the transmitter or pickup and the arrangement on both sides of the plane through the roller centers on each side of the stand permits a structural height of the primary elements which is practically independent of the distance between the roller pivots. These primary elements are in a manner known per se designed for a direct, for instance, inductive contact-free stroke measurement for ascertaining the distance between the rollers or the roller gap. The primary elements are connected to the remaining part of the control device, i.e., the stage for comparing the rated value with the actual value, in such a way that the mean value of the two primary elements of one side of the stand represents the actual value of this side. Inasmuch as the upper part and the lower part of the transmitter or pickup housing are respectively resting against the installation part of the respective working roller, by means of the mean value an inclined position of the installation parts, as it is permissible within narrow limits, is compensated for. The arrangement according to the present invention thus not only broadens the field of application of the heretofore known control devices but also leads to a higher precision of the control and to the elimination of disturbing influences.

According to a particularly advantageous design of the arrangement according to the present invention, the two bearings for the transmitter or pickup housing are divided horizontally so that the outer bearing cup at the dividing gap which in the direction of rotation of the pivot is located in front is linked to the transmitter or pickup housing and at the rearward dividing gap is braced to the transmitter or pickup housing under spring load. This design assures a proper and repeatable adjustment of the transmitter or pickup housing and thereby of the primary element while the construction is relatively simple and a satisfactory control and servicing possibility is obtained.

For obtaining maximum measuring precision of the two primary elements, it is recommended to keep the two parts of the transmitter or pickup housing always in one transverse plane with regard to the axial direction of the rollers. To this end, according to a further feature of the invention, there are between the upper part and the lower part of the transmitter housing provided centering means, for instance in the form of two webs, which are connected to the upper part or lower part and are displaceable relative to each other. These centering means permit a radial displacement of the two parts relative to each other but prevent a relative movement in axial direction of the rollers and in the rolling direction.

Referring now to the drawings in detail, FIGS. **1** and **1***a* illustrate a four high rolling mill stand comprising a pair of working rollers **3**, **4** which together define the rolling bite B and during a rolling operation rest against an upper supporting roller 1 and a lower supporting roller 2 respectively. The central portion of FIG. 1 is more clearly and on a larger scale than in FIG. 1 shown in FIGS. 2 and 3.

As will be seen from FIG. 1*a*, respectively arranged on the roller pivots **6** of the working rollers **3** and **4**, and more specifically between the roller barrels **7** and the supporting members **5** therefor, there is arranged a transmitter or pickup housing **8**, **9**. This transmitter or pickup housing comprising an upper part **8** and a lower part **9**. From the parts **8** and **9** and respectively connected thereto protrude holding arms **10** and **11** extending in the rolling direction. Between these arms **10** and **11** there are installed divided primary elements. The upper parts **12** of the primary elements are in the upper part **8** of the transmitter or pickup housing arranged in a self-arresting manner by means of screws **17**, nuts **18** and loading springs **19**. The lower parts **13** of the primary elements are fastened in the lower part **9** of the transmitter or pickup housing. The outwardly located bearing box **14** of the two parts **8** and **9** of the transmitter or pickup housing is connected to the transmitter housing on one side (FIGS. 3 and 4) by means of a pivotable bearing **15** and on the other side by means of a spring biased screw bolt **16**.

The constructions of FIGS. 1*b* and 1*c* are basically the same as in FIGS. 1 and 1*a* with the exception that FIG. 1*b* shows a six high rolling mill stand, and FIG. 1*c* shows a multi-roller (10) rolling mill stand.

FIG. **5** shows a further development according to the invention according to which between the upper housing part **8** and the lower housing part **9** there is provided a centering arrangement in the form of two webs **20, 21** respectively connected to said upper part **8** and lower part **9** and displaceable relative to each other which permit a radial displacement of the two parts relative to each other while a relative movement in the axial direction of the rollers **3** and **4** and in the rolling direction is prevented.

For purposes of a better understanding of the present invention, FIG. **6** shows a block diagram of a gap control system as it may be used in connection with the present invention. As will be seen from FIG. **6**, the vertical working roller distance is measured directly as close as possible to the roll gap by a noncontact position transducer **22**, in other words, the delivery gage of rolled metal is measured indirectly without deadtime. The relationship between the delivery gage and the workroll gap is given by a factor that is essentially a function of strip width and roll pressure. Hydraulic pushup cylinders adjust the roll and act like an infinitely rigid roll stand to compensate for any elastic vertical deflection due to roll pressure variations. The speed response of the hydraulic system is large determined by the capacity of the hydraulic pump P and the servovalves per unit of time.

For the design of such a system, several basic but very important factors must be considered. The necessary design considerations should include: gage deviations of ingoing metal; maximum frequency of deviation; rate of change of deviation; desired finished gage; required gage tolerances. The absence of contact protects the position transducer against damage by axial thermal expansion of the rolls, and at the same time facilitates roll changes. Depending on working conditions, one may choose between inductive, electromagnetic and optical position transducers, and distance-measurement devices. The choice should depend on the roll coolant, the working temperature and, eventually, on vibrations in the roll stand. In general, the feedback signal from the transducer should have a precise and stable zero point, high resolution, and repeatability (0.001 mm). The transducer time constants should be small (1 to 2 millisec), and there should be absolute linearity between the feedback and the reference.

The mechanical design must be such that after each roll change it is possible to establish automatically a zero position by moving the rolls together (when the roll assembly with transducer is inserted in the mill stand, no adjustment by hand can be made). Also, it should be possible to set and monitor the reference roll gap from a remote control station.

The time constant of the control system must be adjustable over a wide range in order to obtain optimum matching to all parts of the closed loop. The control cabinet must be provided with input terminals for correction signals that have to be added. The roll gap measurement system described here does not pick up changes in work roll flattening if roll pressure changes occur during rolling. Therefore, under certain circumstances, the roll gap reference value has to be corrected by prepared signals from load cells installed in the mill stand. Furthermore, long-term deviations sensed with a conventional X-ray gage meter (changes in thermal roll-crown, for example) can be integrated over a period of time and then used for correcting the reference.

The power output of the control unit must be sufficient to actuate several electrohydraulic servovalves mounted in parallel. The control unit should allow closed-loop servo response in the system to be independent of the roll gap magnitude. The overall design of the hydraulic system should be such that any roll gap deviation can be compensated within a few milliseconds. To keep the time constant of the control circuit low, several small servo-valves in parallel are used.

FIG. **7** illustrates the sensing principle and the schematic diagram of an inductive transducer system for use in connection with the present invention. Sensing variable inductance I (feed back signal generator), with its air gap proportional to the roll gap, is connected in a bridge circuit with variable reference inductance S (adjustable reference signal generator) and two fixed inductances I_v and S_v, I_v standing for auxiliary inductance (feed back) and S_v standing for auxiliary inductance (reference). All four inductances have the same electrical values and the same geometry

As to the remaining elements in FIG. **7**, the circuit comprises an alternator G, a rectifier D in proper phase, a regulator R, an output element St (in the roll stand), a filter F and a servo-potentiometer P turning in the same direction as the reference signal generator S.

FIG. **8** shows the mechanical construction of the sensing system, which is identical for both reference and feedback. Combining two halves of the bridge system (I and I_v) in one transducer assembly makes the system immune to the large variations in coil resistance R_{cu} caused by temperature changes. If the temperature changes more than 50° C during one pass, which is possible in hot mills, an additional temperature compensation may be effected by thermistors inserted in series with the coil windings.

The symmetrical arrangement and the electromagnetic shielding of the transducer assembly reduce variations in inductance and ensure that the relationship between air gap and control signal is not disturbed by any extraneous effected of electromagnetic interference. The frequency of generator voltage supplied for the bridge system is chosen so as to give a difference in relation between inductance and coil resistance. This transducer system is not affected by the roll cooland used by cold rolling industries. Also, because of its low alternating current inductance, it is suitable for rolling ferromagnetic materials.

It is, of course, to be understood that the present invention is, by no means, limited to the particular showing in the drawings but also comprises any modifications within the scope of the appended claims.

What we claim is:

1. An arrangement of primary elements for controlling roller gap, especially of four high and multi-roller systems, which includes: roller stand means, a pair of working rollers associated with each other and each including a roller pivot, two transmitter housing means respectively arranged on said roller pivots and respectively located at each side of said roller stand means, each of said housing means having an upper section and a lower section, each of said working rollers having a roller barrel, a pair of assembly members respectively having said roller pivots journaled therein, first journaling means for journaling the upper section of each housing means in a substantially play-free manner on the roller pivot of the pertaining upper roller between the pertaining assembly member and the pertaining roller barrel, and second journaling means for journaling the lower section of each housing means in a sbustantially play-free manner on the roller pivot of the pertaining lower roller between the pertaining assembly member and the pertaining roller barrel, each of said two sections being provided with two holding arms respectively extending forwardly and rearwardly with regard to said rollers when viewing the rolling direction thereof, a first primary element arranged between the two forwardly extending arms of said sections, and a second primary element arranged between the two rearwardly extending arms of said two sections.

2. An arrangement according to claim **1**, in which the first and second journaling means are split so as to form a substantially horizontal gap each, and in which each of said first and second journaling means includes an outer bearing cup, each of said outer bearing cups having its front portions when viewing in the direction of rotation of said roller pivots linked to the respective adjacent transmitter housing means and having its rear portion against spring thrust connected to the rear portion of the respective adjacent transmitter housing means.

3. An arrangement according to claim **1**, in which at least one of the sections of said housing means is provided with means for permitting a radial displacement of said sections relative to each other while preventing said sections from moving relative to each other in the axial direction of said working rollers.

4. An arrangement according to claim **3**, in which said means include webs respectively connected to said upper and lower sections slidable relative to each other.

* * * * *