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**2,696,264**

## FLEXIBLE WELL LINER

Filed Oct. 15, 1951

3 Sheets-Sheet 1

The image contains five technical drawings of a mechanical device, labeled Fig. 1 through Fig. 5.

- Fig. 1** (top left): A side cross-sectional view of a vertical assembly. It shows a central shaft (12) with a series of vertical slots (13, 14, 15, 16, 17, 18, 19, 20, 21, 22). The shaft is surrounded by a housing (23) with a flange (24) at the top. A screw (25) is shown securing the flange. A dashed line indicates a hidden internal feature.
- Fig. 2** (top right): A cross-sectional view of a component, possibly a valve or a plug. It shows a central shaft (26) with a flange (27) and a series of vertical slots (28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807

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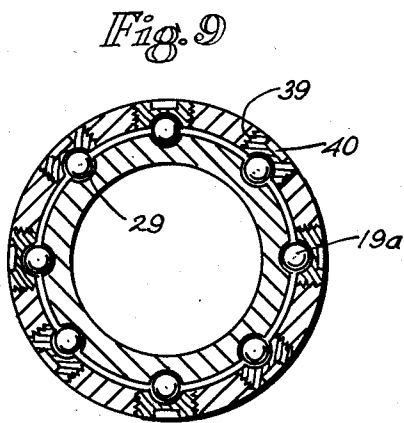
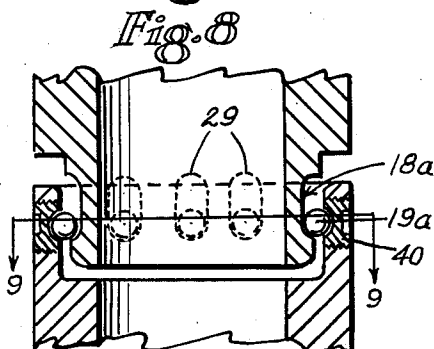
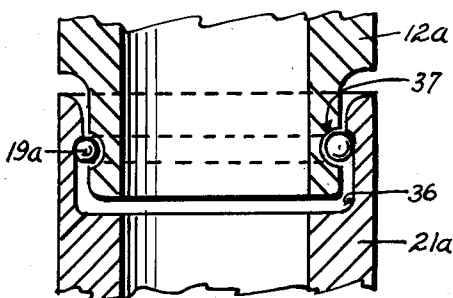
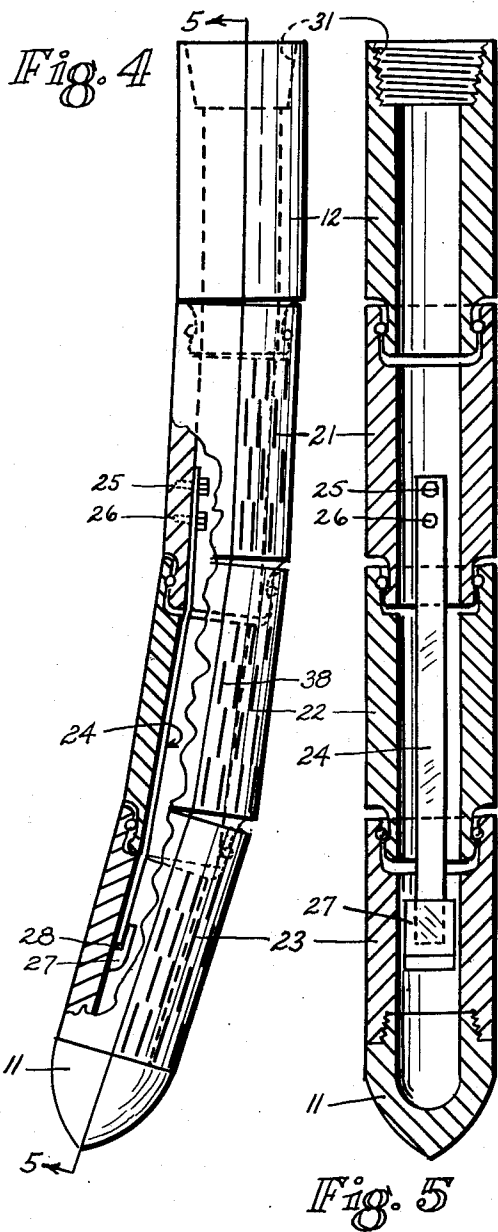
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3 Sheets-Sheet 2



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FLEXIBLE WELL LINER

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3 Sheets-Sheet 3

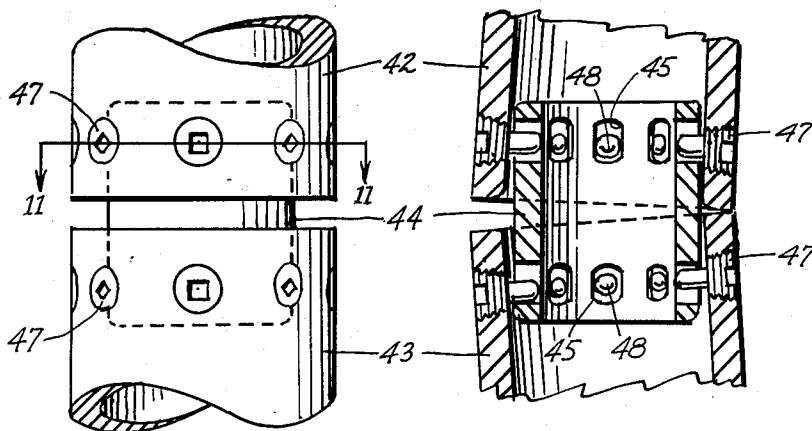


Fig. 10

Fig. 14

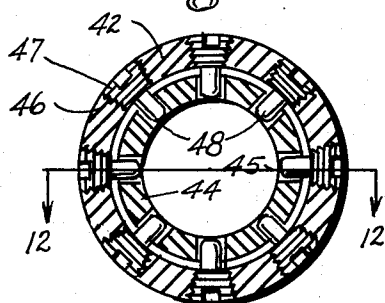


Fig. 11

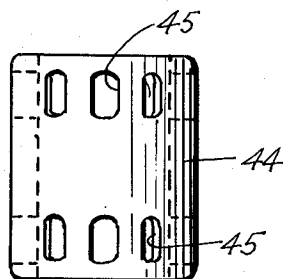


Fig. 13

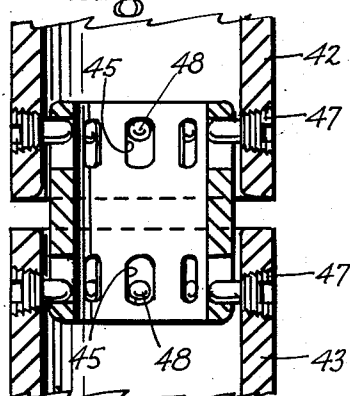


Fig. 12

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1

2,696,264

## FLEXIBLE WELL LINER

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4 Claims. (Cl. 166—235)

This invention relates to perforated liners or screens for oil wells and more particularly to an articulated liner which is sufficiently flexible to be used in wells which have been drilled so as to deviate from the perpendicular.

A method has been developed for successfully drilling wells arcuately away from the main vertical bore so as to complete the wells horizontally in the oil-producing formation. Several such lateral bores or "drain holes" may be drilled from a single vertical main bore hole. The lateral bores or "drain holes" leave the main vertical bore in an arc having a relatively long radius and gradually assume an approximately horizontal direction. The advantage gained by the drilling of such horizontal drain holes is an increased rate of production owing to the greater lineal length of the producing section of the oil sand.

In many oil fields it is necessary to provide some means for preventing the slough of the oil sands which would otherwise plug up the pump or the bore hole. In the case of vertically drilled wells this has been accomplished by placing a perforated liner or well screen throughout the thickness of the oil-producing zone. Sometimes these liners or screens are packed externally with gravel to further retard the entrance of sand into the well bore. In the case of horizontally drilled wells it has been the practice to fill the lateral drain holes with tamped gravel, since it is impossible to run a conventional rigid liner through the arcuate section of the bore hole. The practice of tamping gravel into the lateral drain holes is not as satisfactory as the use of conventional perforated liners or well screens.

It is the purpose of the present invention to provide an articulated liner or well screen which can be run through the arcuate section of the well bore to the end of a horizontal drain hole.

Another object is to provide an articulated liner or well screen with flexible means for guiding it from the vertical portion of the well bore into the arcuate section of the well bore.

Another object is to provide a simple, strong and inexpensive flexible joint for such liners or well screens.

Figure 1 illustrates a vertical bore hole having a lateral drain hole with an articulated, flexible liner in place.

Figure 2 illustrates one form of the articulated liner showing the method of forming the flexible joint.

Figure 3 illustrates an alternative form of flexible joint of the bell and spigot type.

Figure 4 shows a side elevation, partly in cross section, of an articulated liner with a pre-set curvature to enable the liner to enter a lateral drain hole.

Figure 5 is a cross-section taken on line 5—5 of the liner shown in Figure 4.

Figure 6 is cross-section taken on line 6—6 of Figure 2 showing a form of locking means for preventing relative rotation of the adjacent sections of the articulated liner.

Figure 7 illustrates a modification of the flexible joint shown in Figure 2.

Figures 8 and 9 illustrate another modification of the flexible joint.

Figures 10 to 14 illustrate still another modification of the invention.

In the drawings, a vertical well bore is indicated at 1 extending downwardly from the surface of the earth 2 and

2

provided with the usual well casing 3 cemented in place as indicated at 4. The casing shoe is indicated at 5.

A lateral drain hole 6 extends from the vertical bore 1 in an arcuate curve 7 ending in a horizontal extension 8.

A conventional liner hanger 9 positioned in the well casing 3 above the casing shoe 5 serves as a support for an articulated, flexible liner or well screen 10. The lower section of the liner 10 is closed by a bull plug 11.

The sections of the liner 10 are flexibly connected together, as by the arrangement illustrated in Figure 2. The lower end of a section of liner is indicated at 12. The outside diameter of the liner is progressively reduced as indicated at 13 and 14 to form an elongated ball race 14 terminating in a shoulder 15.

The male end section of reduced diameter is received within the upper or female end of the adjoining liner section 16. The inner face of the female section 16 is counter-bored to provide a loose fit between the male and female members as indicated by the gap 17. A ball race 18 is formed in the inner face of the female section 16 near the upper end thereof. Balls 19 fill the space between the ball races 14 and 18. The balls are inserted through an opening which is closed by a plug 20.

The elongated ball race 14 together with the clearance gap 17 permits adjacent sections of the liner 21, 22, 23 to have a limited pivotal movement which gives flexibility to the whole liner assembly 10.

When the flexible liner is being run into the well bore it is essential that some means be provided to insure that bull plug 11 on the lower end of the liner be guided into the entrance 7 to the lateral drain hole 8. For this purpose there is provided the arrangement shown in Figures 4 and 5. A stiff leaf spring 24 is pre-formed into an arc sufficient to force the bull plug 11 beyond the wall of the well casing 3. The upper end of the spring 24 is secured to the inner face of one of the lower sections 21 of the liner, as by the bolts 25 and 26. The lowermost liner section 23 is provided with a bracket 27 having an upwardly facing pocket 28 which loosely receives the lower end of the spring 24. It is not necessary to provide the intermediate liner sections 22 with any fastening means for the spring 24. The uppermost section 12 of the liner is provided with means, such as the threads 31, for attachment to a liner hanger 9 (Figure 1).

The liner 10, attached to the liner hanger 9, is lowered into the bore hole 1 on a string of tubing and may be oriented by well known means so as to bring the bull plug 11 opposite the entrance 7 to the drain hole 8. The spring 24 is preformed in an arc such that the height of the segment of the circle represented by the arc is great enough so that when the bull plug 11 comes opposite the entrance 7 to the drain hole 8 it will enter same and guide the liner into position.

The intermediate sections 21 and 22 of the liner 10 may be held against relative rotation by means other than the spring 24 and the brackets 27. For example, as shown in Figure 6, the inner ball race 14 and the outer ball race 18 are each provided with a pair of spaced lugs 32 and 33, respectively, adapted to straddle one of the balls 19, thereby preventing relative rotation of the members 12 and 14.

Figure 3 illustrates a modification of the flexible joint shown in Figure 2 wherein a bell and spigot joint is used in order to retain a full hole inside diameter without reducing the wall thickness of the mating members. The bell is indicated at 34 and the spigot at 35. The method of flexibly joining the members 34 and 35 is the same as that described in Figure 2.

Figure 7 illustrates another modification of the joint shown in Figure 2. In Figure 2 the elongated ball race 14 is formed in the male extension on the member 12. In Figure 7 the elongated ball race 36 is formed in the female member 21a and the other ball race 37 is formed in the male extension on the member 12a.

Figures 8 and 9 illustrate another modification of the flexible joint in which the anti-rotation lock includes a series of grooves 29 formed in the outer surface of the male extension on the liner section. The grooves 29 are elongated axially of the liner section and are disposed

around the male extension to receive locking balls 19a. The latter may be confined in a ball race 18a formed in the inner face of the female end of the adjoining liner section, as shown in Figure 8, or they may be inserted in individual holes 39 formed in the female member as shown in Figure 9. The holes 39 may be tapped to receive threaded plugs 40 to retain the balls 19a in position.

With the construction shown in Figures 8 and 9 the joint between adjacent liner sections can flex but the sections can not rotate with respect to each other.

The liner sections 12, 21, 22, and 23 may be perforated with round holes or slots and may be wire wrapped if desired. Also, the liner sections can be prepacked on the outside with gravel or other filtering material, in the conventional manner.

Inasmuch as when the liner is in operative position in the lateral drain hole, it will lie in an approximately horizontal position, it may be preferred to perforate only the sides and bottom of the liner, leaving the upper surface blank, as shown in Figures 4 and 5. The perforations are indicated at 38.

Figures 10 to 14 illustrate still another modification of the invention wherein adjacent liner sections are coupled together, flexibly, by a short coupling sleeve.

Figure 10 is a fragmentary elevation of a coupling sleeve.

Figure 11 is a cross section taken on lines 11—11 of Figure 10.

Figure 12 is a vertical cross section of the device shown in Figures 10 and 11 taken on lines 12—12 of Figure 11.

Figure 13 is an elevation of the coupling sleeve.

Figure 14 is a vertical cross section similar to Figure 12 but showing the liner sections in a flexed position.

In the coupling arrangement illustrated in Figures 10 to 14, the upper liner sections are indicated at 42 and the lower sections at 43. A short coupling sleeve 44 of slightly smaller outside diameter than the inside diameter of the liner sections 42 and 43 connects the adjacent ends of the liner sections. Each end of the coupling sleeve is loosely attached to the corresponding end of the liner sections, as by the pin and slot arrangement shown in Figures 10 to 13, or by balls, as shown in the preceding figures. The pin and slot arrangement is simple and sturdy and does not permit relative rotation of adjacent liner sections. In this construction, a series of slots 45 are formed near each end of each coupling sleeve. The adjacent end of each liner section 42, 43 is provided with a series of threaded holes 46 adapted to receive the threaded plugs 47. The plugs 47 are preferably formed with smooth pin extensions 48 on their inner ends, adapted to engage the slots 45.

When the liner sections and coupling sleeves are assembled, they can flex as shown in Figure 14 but the liner sections can not rotate with respect to each other.

If desired, balls can be substituted for the pins 48, as illustrated in Figure 9 or 6.

Other modifications of the invention are possible, within the scope of the following claims.

We claim:

1. A perforated well liner comprising a series of articulated liner sections, coupling sleeves loosely mounted within adjacent ends of the liner sections, perforations in said coupling sleeve adjacent each end of same, and pin means adjacent the ends of said liner sections adapted to engage the perforations in said coupling sleeves to secure the sleeves in said liner sections and to prevent relative rotation of same.

2. A perforated well liner comprising a series of articulated liner sections, coupling sleeves mounted within adjacent ends of the liner sections, longitudinally extending recesses adjacent at least one end of said coupling sleeves and pins in said liner sections near the ends thereof and extending radially inwardly to engage in the recesses in said liner sections whereby the liner sections are flexibly but relatively non-rotatably connected together.

3. A perforated well liner comprising a series of articulated sections provided with male and female mating members, circumferentially spaced recesses formed in the outer surface of said male members, and pins, in said female members extending radially inwardly and engaging said recesses, the outside diameter of said male members being slightly less than the inside diameter of said female members whereby the joint between the mating liner sections can flex.

4. In a perforated well liner, tubular liner sections of like diameter, and means for coupling adjacent ends of the sections together to permit limited relative angular movement therebetween, the transmitting of turning movement from one to the other and the transmitting of longitudinal movement from one to the other by a direct abutting engagement between the coupling ends, said coupling means comprising a sleeve member mounted within the adjacent end and connected thereto, at least one of the ends of the sleeve member being loose in the end of the tubular member in which it is received, and the connection therewith comprising radially extending pins carried by the end of one member and openings in the end of the other member receiving the pins, said openings being larger than the pins at least in their longitudinal direction and the pins and openings being so positioned with respect to the connected ends of the tubular members that said ends can be moved into abutting relation.

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